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V4-B2707-4

PHASE III PROPOSAL

SUPERSONIC TRANSPORT DIV

SEPTEMBER 6, 1966

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Volume IV-4.

AIRPORT AND COMMUNITY NOISE PROGRAM,

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Office of Supersonic Transport Development Program

THE BOEING COMPANY
SUPERSONIC TRANSPORT DIVISION

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ISSUE NO. 1 2

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FOREWORD

ENGINE AND AIRPLANE PERFORMANCE DATA

The engine and airplane performance provided in the main body of this document is based on engine performance data received prior to 15 July 1966.

The RFP provides for firm technical engine data to be submitted on 8 August 1966. The predicted effect of this data is of interest to the readers of this document. Accordingly, an addendum summarizing the effect of the 8 August 1966 engine performance on the B-2707 SST has been inserted into the following documents:

V2-B2707-3	Aerodynamic Design Report
V2-B2707-12	Propulsion Report - Part A
V4-B2707-1	Operational Suitability Report
V4-B2707-4	Airport and Community Noise Program

The performance information contained in the Summary document, the Model Specification, and the Statement of Work is based upon the 8 August 1966 firm technical data.

CONTENTS

1.0 INTRODUCTION

The Airport and Community Noise Program is called for by FAA Request for Proposal for Phase III of the SST Development Program. The Airport and Community Noise Program is part of Vol. IV, Systems Integration. The purpose of this document is:

a. To present the airport and community noise characteristics of the B-2707 airplane with each of the offered engines installed.

b. To present the airport and community noise characteristics of the B-2707 airplane with a Boeing jet suppressor installed on each of the offered engines.

c. To present the Boeing predictions of the installed noise characteristics of the offered engines, together with the background and procedures used to arrive at these predictions. It will include a discussion of the effects of noise suppression devices on installed noise levels.

d. To present an airport and community noise activities program, with detailed activities work plan tasks and schedules, to satisfy the RFP, Sec. 5-IV-A.2.d and e.

The excellent low-speed flight characteristics of the B-2707 together with the high thrust loading and noise suppression capabilities of the propulsion system, provide great flexibility to the operator in adapting to the various airport noise restrictions. Specifically, the B-2707 will provide the flexibility to:

a. Meet FAA objectives of 116PNdB at the airport and 105PNdB in the community during takeoff and climbout.

b. Meet the FAA objective of 109PNdB in the community during landing approach.

c. Maintain low noise levels during ramp and taxi operations.

Realizing the importance of further noise reductions Boeing is continuing an intensive research and development effort to provide more effective means of noise suppression. Some of the results of this program are covered in this document and a complete report on this work is included in Propulsion Report, V2-2707-13.

Additional airport and community noise discussions may be found in Aerodynamic Design Report, V2-B2707-3, Airplane Performance (GE), V2-B2707-4, Airplane Performance (P&WA), V2-B2707-5, and Operational Suitability, V4-B2707-1, in which operational techniques are integrated with engine noise characteristics, and in the Phase II-C study reports, Airport Compatibility Analysis, in which noise contours have been applied to specific airports. Noise alleviation by means of airplane design is discussed in System Engineering Report, V2-B2707-1.

2.0 B-2707 NOISE CHARACTERISTICS

The noise environment at the airport and the community during takeoff, departure, landing approach, ground operations, and maintenance has been predicted by combining GE4/J5P and P&WA JTF 17A-21B engine noise characteristics with the performance characteristics of the B-2707. The predicted noise characteristics of each engine have been based on two different engine exhaust nozzle configurations: 1) The configuration offered by the engine contractor and 2) an advanced suppressor configuration to be made available by Boeing for the B-2707. In establishing the noise environment of the B-2707 Boeing has also included the inlet noise suppression achieved by use of the Boeing designed sonic inlet.

Table 2-A. Airport and Community Noise Levels with Engine Manufacturers Jet Suppression

TAKEOFF WEIGHT, ~1,000 LB	TEMP.	FIELD ALTITUDE, FT.	AIRPORT NOISE, ○ PNdB		COMMUNITY NOISE, ● PNdB	
			B-2707 P & WA	B-2707 (GE)	B-2707 P & WA	B-2707 (GE)
MAXIMUM AUGMENTED TAKEOFF - NOISE ABATEMENT CLIMBOUT						
INTERNATIONAL						
675	59°F	0	117.0	121.0	105.0	100.0
675	86°F	0	116.5	120.5	112.0	107.0
675	52°F	2,000	116.5	120.5	108.0	104.0
675	45°F	4,000	116.0	120.0	112.5	108.0
*PART POWER TAKEOFF – NOISE ABATEMENT CLIMBOUT						
DOMESTIC						
575	59°F	0	115.0	117.0	102.0	99.0
575	86°F	0	114.5	116.5	107.0	105.0
575	52°F	2,000	115.5	116.5	105.0	104.0
575	45°F	4,000	114.0	116.0	108.0	108.0

*MAXIMUM DRY POWER FOR B-2707 (GE)
.5 AUGMENTED POWER FOR B-2707 (P&WA)

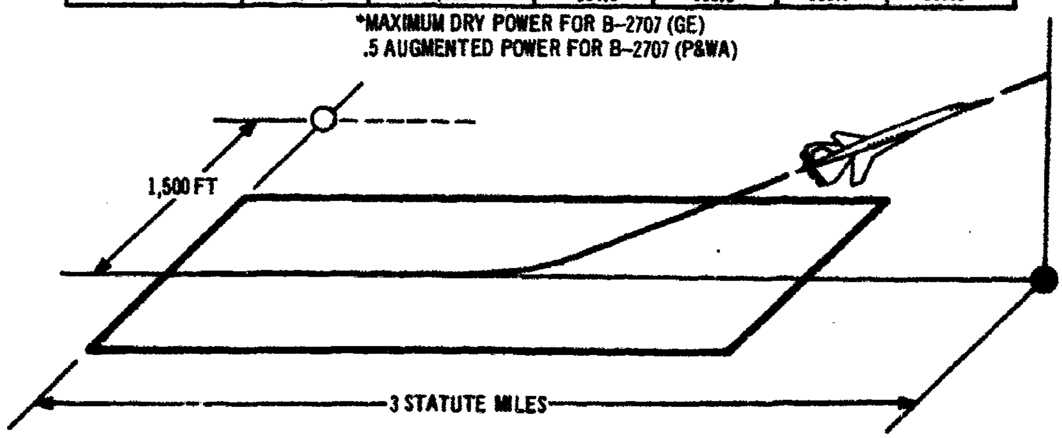
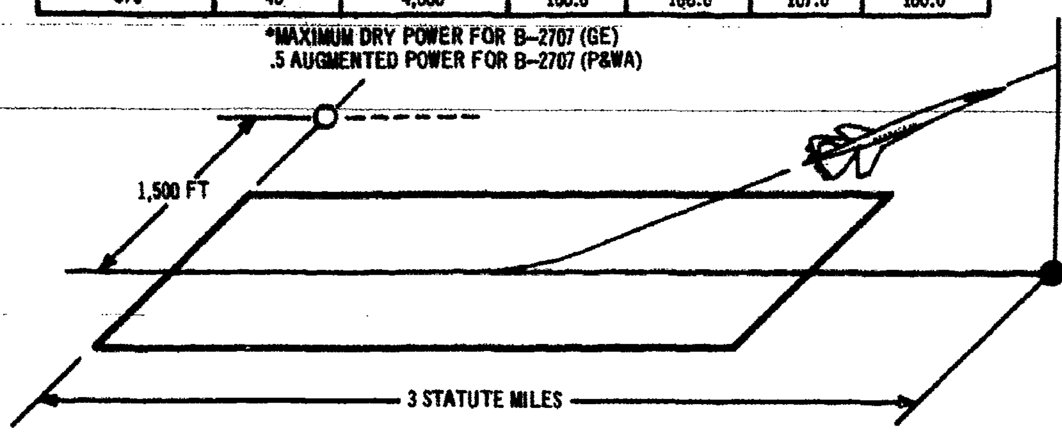


Table 2-B. Airport and Community Noise Level with Boeing Jet Suppression

TAKEOFF WEIGHT ~1,000 LB	TEMP	FIELD ALTITUDE FT	AIRPORT NOISE ○ PNdB B-2707 (P&WA)	AIRPORT NOISE ○ PNdB B-2707 (GE)	COMMUNITY NOISE ● PNdB B-2707 (P&WA)	COMMUNITY NOISE ● PNdB B-2707 (GE)
MAXIMUM AUGMENTED TAKEOFF – NOISE ABATEMENT CLIMBOUT						
INTERNATIONAL						
675	59°	0	113.0	112.0	103.5	98.0
675	86°	0	112.5	111.5	110.0	105.0
675	52°	2,000	112.5	111.5	106.0	102.0
675	45°	4,000	112.0	111.0	111.0	106.0
*PART POWER TAKEOFF – NOISE ABATEMENT CLIMBOUT						
DOMESTIC						
575	59°	0	109.0	109.0	101.0	96.0
575	86°	0	108.5	108.5	106.0	103.0
575	52°	2,000	108.5	108.5	104.0	102.0
575	45°	4,000	108.0	108.0	107.0	106.0

*MAXIMUM DRY POWER FOR B-2707 (GE)
.5 AUGMENTED POWER FOR B-2707 (P&WA)



2.1 TAKEOFF NOISE

The noise levels predicted for the airport and community during takeoff and climbout of the B-2707 International (675,000 lb gross weight) and the B-2707 Domestic (575,000 lb gross weight), for a number of airport altitudes and ambient temperature conditions are given in Table 2-A with the engine manufacturers nozzles and in Table 2-B for the Boeing suppressors. The community noise levels shown are based on a maximum augmented thrust takeoff with a thrust reduction that results in an unaccelerated rate of climb of 500 fpm at a point one statute mile beyond the departure end of the runway. The thrust reduction is smooth beginning several seconds before reaching the three mile point, thus achieving the thrust required for 500 fpm rate of climb as the airplane passes over the three mile point. The resulting altitude and engine thrust requirement produce a noise level in the community at the three mile point of 100PNdB (GE Suppression) and 98PNdB (Boeing Suppression) for the B-2707 (GE) International airplane at 675,000 pounds takeoff gross weight and 105 PNdB (P&WA Suppression) and 104 PNdB (Boeing Suppression) for the B-2707 (P&WA) International airplane at the same gross weight. The decrease in airport noise with increase in ambient temperature and airport altitude is the result of changes in two jet engine parameters: 1) jet velocity and 2) jet density. The increase in community noise with increase in ambient temperature and airport altitude is the result of changes in 1) engine jet

velocity and density and 2) reduced climb-out rate and therefore reduced altitude over the community.

The changes in airport and community noise levels as functions of takeoff power and airplane gross weight are shown in Figs. 2-1, and 2-2, for the airplane equipped with jet suppressors as provided by the engine manufacturer and in Figs. 2-3 and 2-4, for the airplane equipped with Boeing jet suppressors. The large reductions in both airport and the community noise levels afforded by the Boeing jet suppressor are readily apparent.

The noise exposure contours below and to the side of the airplane takeoff flight path resulting from standard noise abatement techniques on a standard day are presented in Figs. 2-5 through 2-12. The predicted noise levels are in units of both PNdB (Figs. 2-5 through 2-8) and PNdB seconds (Figs. 2-9 through 2-12). Units of PNdB are based on the maximum noise heard by the observer regardless of time or direction of the noise. Units of PNdB seconds are based on the maximum instantaneous PNL with correction factors for time duration of the noise and for the presence of discrete frequency noise in the total noise spectrum. The method used in calculating PNdB seconds is given in Ref 1. Use of a sonic inlet, and fan duct acoustic lining in the case of the turbofan engine, reduces the discrete frequency content of the noise; climbout at increased speed minimizes the effect of time duration. As a consequence, the noise exposure contours calculated in PNdB seconds are not appreciably different from noise contours calculated in PNdB directly under the flight path. However, sideline noise does increase when measured in PNdB seconds because of the correction factor for time duration. The predicted noise level contours (PNdB) for the B-2707 (GE) and B-2707 (P&WA) International airplanes equipped with Boeing suppressors are presented in Figs. 2-13 and 2-14. The reduction in lateral spread of the noise as well as the absolute noise level is apparent.

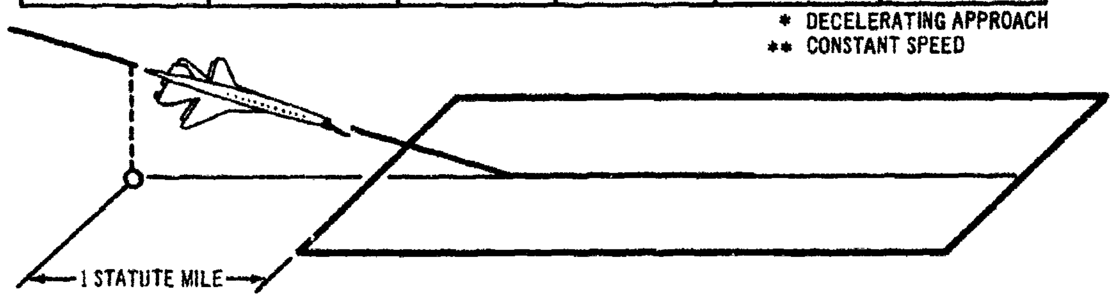
2.2 LANDING APPROACH

Approach noise one mile from the end of the runway with the airplane flying a 3-deg glide slope ILS approach is tabulated in Table 2-C. For a

Table 2-C. Landing Noise Levels

AIRPLANE	LANDING WEIGHT 1000 LB	COMMUNITY NOISE O, PNdB			
		SEA LEVEL 59°F	SEA LEVEL 86°F	2,000 FT ALT 52°F	4,000 FT ALT 45°F
B-2707 (P&W)	* 420	111	112	112	113
	** 420	115	116	116	117
	* 400	111	112	112	113
	** 400	115	116	116	117
B-2707 (GE)	* 430	108	109	109	110
	** 430	112	113	113	114
	* 410	108	109	109	110
	** 410	112	113	113	114

* DECELERATING APPROACH
** CONSTANT SPEED



standard day at maximum landing weight, the PNL is predicted to be 112 PNdB and 115 PNdB for the B-2707 (GE) and B-2707 (P&WA) airplanes respectively. The use of a sonic inlet and treated duct lining lowers the PNL and reduces the annoyance factor commonly connected with the presence of pure tone (whine) in the landing noise spectrum. By scheduling a maximum nozzle throat area at landing the jet velocity is lowered, thus reducing the low frequency noise to a level where it will not be a problem.

The noise levels below and to the side of the airplane landing approach path for a 3 deg glide slope are shown in Figs. 2-15 through 2-18 for both airplanes. Noise contours in units of PNdB (Figs. 2-15 and 2-16) and PNdB seconds (Figs. 2-17 and 2-18) are shown. Because of the short time duration during landing approach fly-over, the maximum PNdB seconds noise level directly under the flight path is less than the noise calculated in units of PNdB. Also shown, at two points in the community, are noise levels that would be experienced if the engines were not suppressed. Substantial improvement has been made through suppression not only in the maximum level but in the spread of noise to the side of the flight path.

2.3 GROUND OPERATIONS

Noise levels resulting from ground operations near airport terminals (taxi, etc.) are comparable with those presently experienced with large subsonic jet transport operations. Maximum PNL's along a line 200 ft distant from the airplane's line of taxi will not exceed 1[illegible]2 PNdB for either the B-2707 (GE) or B-2707 (P&WA) airplane (see Fig. 2-19). These low noise levels are the result of near sonic conditions in the inlet, acoustic treatment in the fan discharge duct, and reduced jet velocities from the engine tailpipes. With variable-area inlets in the minimum-throat position, which is the normal case for ground operations, the engines' air demand for taxi thrust raises the inlet throat Mach number to about 0.8. Although this is below sonic flow, tests have shown that inlet noise is attenuated 10dB or more at these velocities (Par. 4.2 and Ref. 2). Jet velocities are low because of the open tailpipe concept used on both engines at reduced power. The taxi noise levels are based on a taxi thrust requirement of 3 percent of the gross weight of the airplane.

2.4 MAINTENANCE RUNUPS

It is expected that at some maintenance bases, ground-runup suppressors will be used for extended maintenance testing at high power. Ground runup suppressors offering 25dB noise reductions will be available. With their use, the maximum PNL that will be experienced at a distance of 1,500 ft from the engine during maximum augmentation will be 99 PNdB with the GE 4/J5P engine and 97 PNdB with the P&WA JTF17A-21B engine. Maintenance personnel stationed at necessary positions near the airplane during such runups will not be subjected to overall sound pressure levels (SPL) in excess of 140dB nor to speech interference levels (SIL) above 130dB. A plot of the suppressed noise levels for both engines is shown in Fig. 2-20. The predicted spectra for 1,500 ft and for the near field are shown in Fig. 2-21.

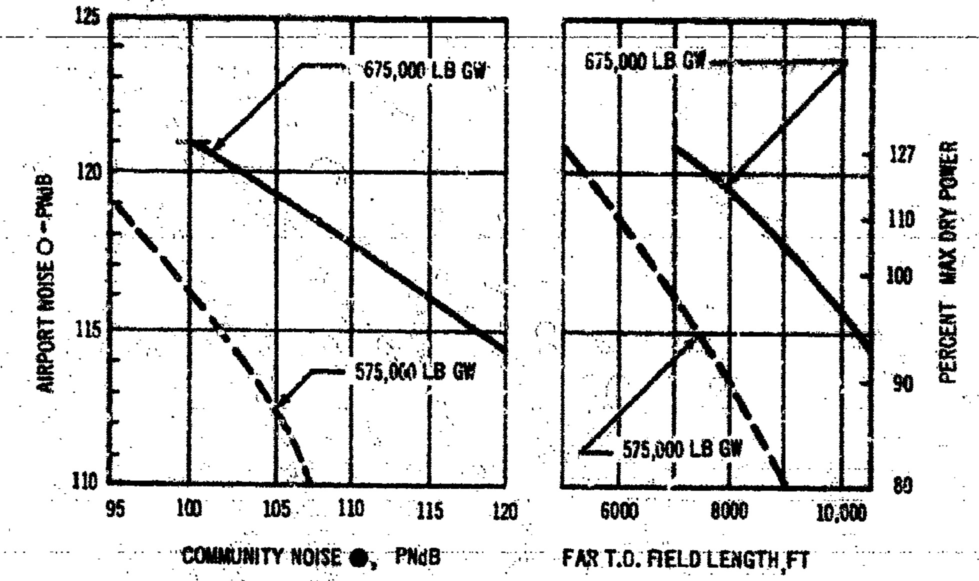


Figure 2-1. Airport – Community Noise Trades B-2707 (GE) With Engine Manufacturers Jet Suppression

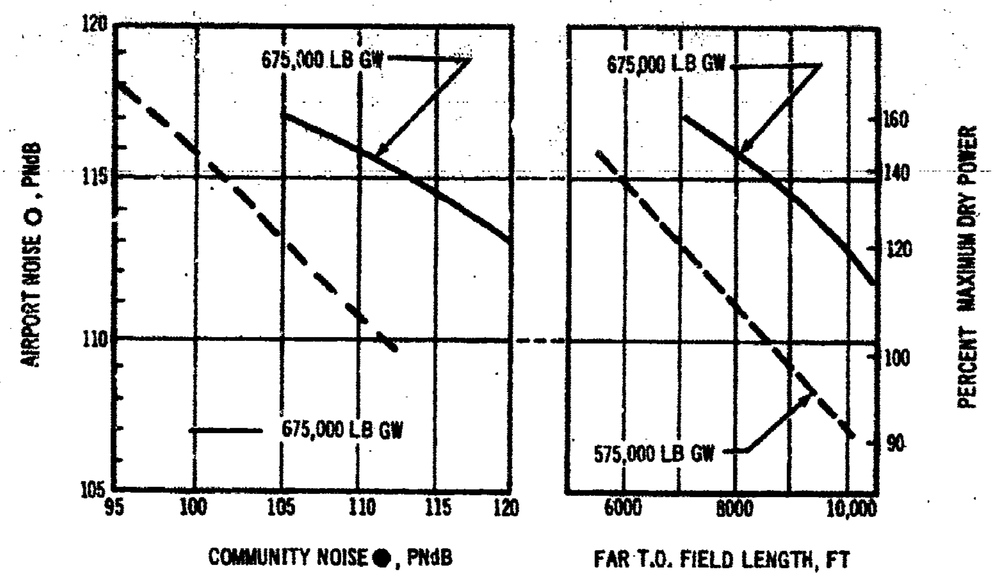


Figure 2-2. Airport – Community Noise Trades B-2707 (P&WA) With Engine Manufacturers Jet Suppression

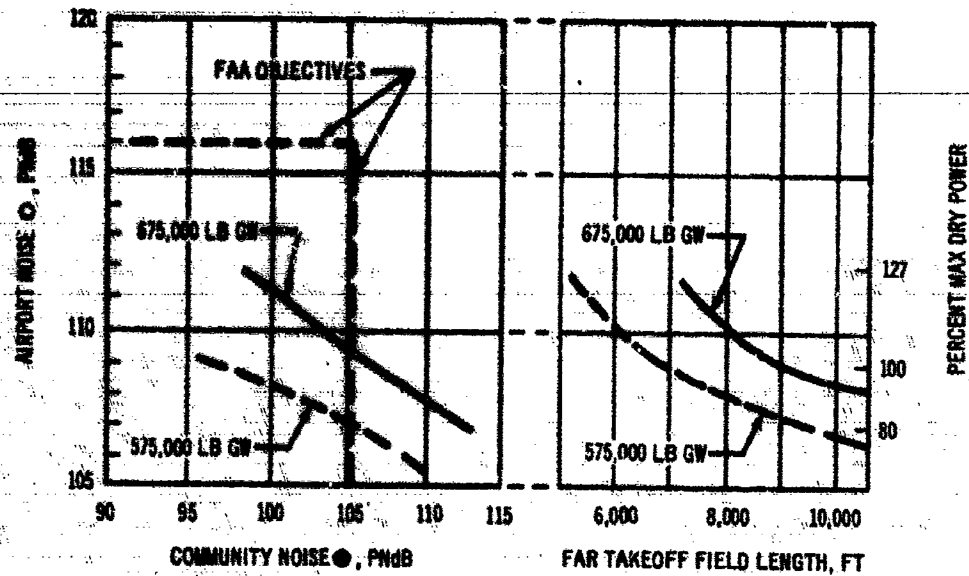


Figure 2–3. Airport – Community Noise Trades B–2707 (GE) with Boeing Jet Suppression

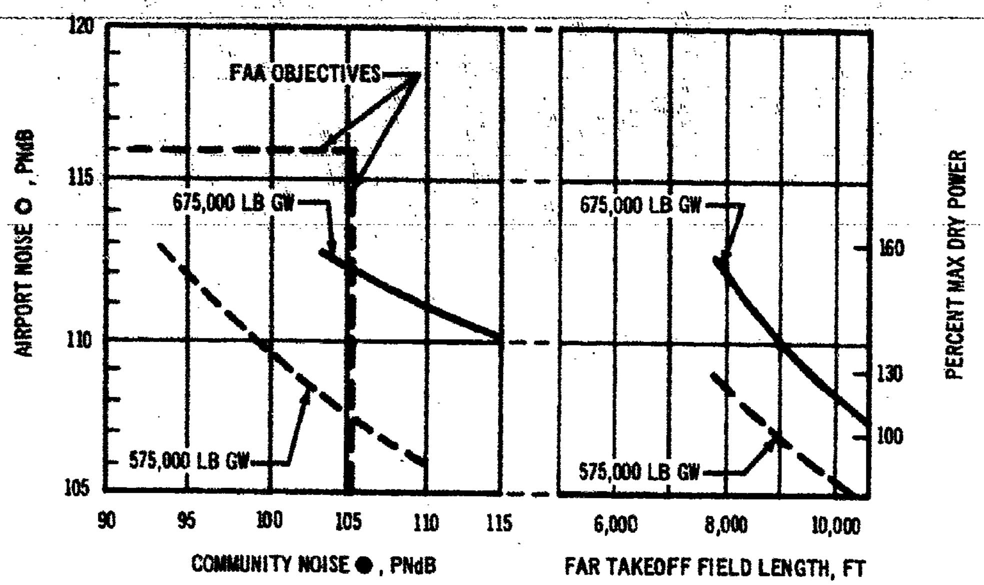
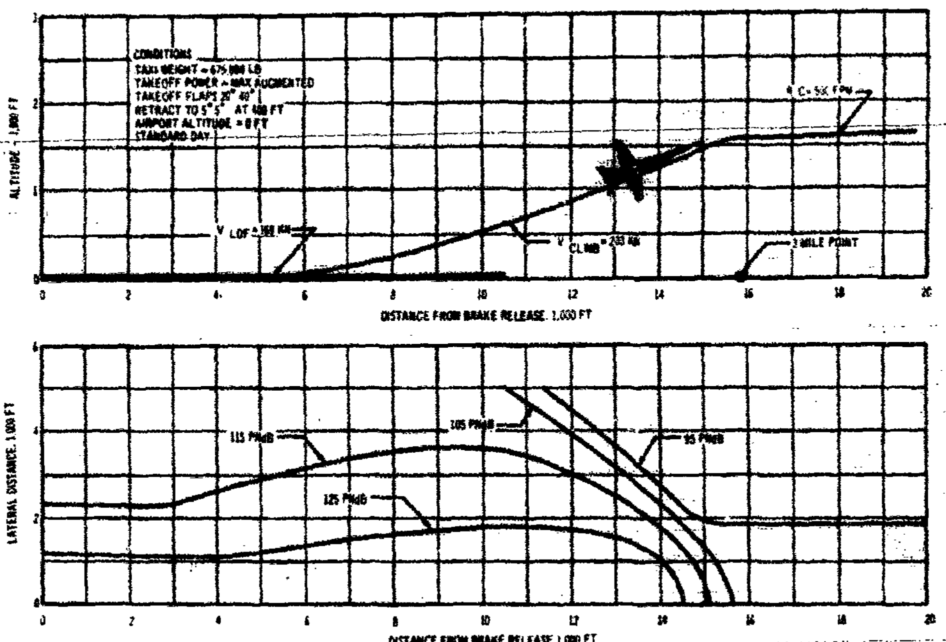
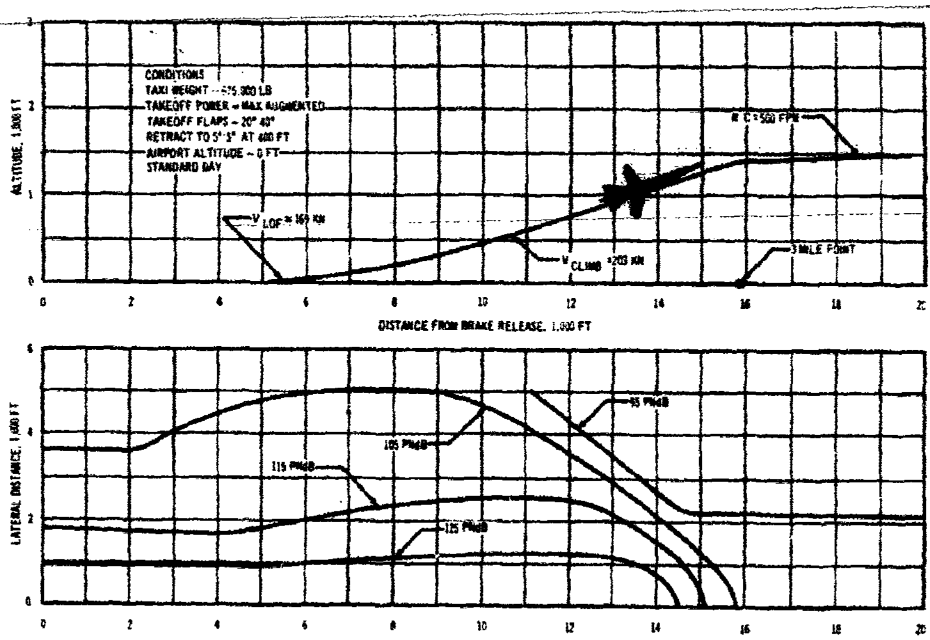


Figure 2–4. Airport – Community Noise Trades B–2707 (P&WA) with Boeing Jet Suppression



1 IN = 2,000 FT

Figure 2–5. Perceived Noise Level Contours for Takeoff, B–2707 (GE) International Mission



1 IN = 2,000 FT

Figure 2–6. Perceived Noise Level Contours for Takeoff B–2707 (P&WA) International Mission

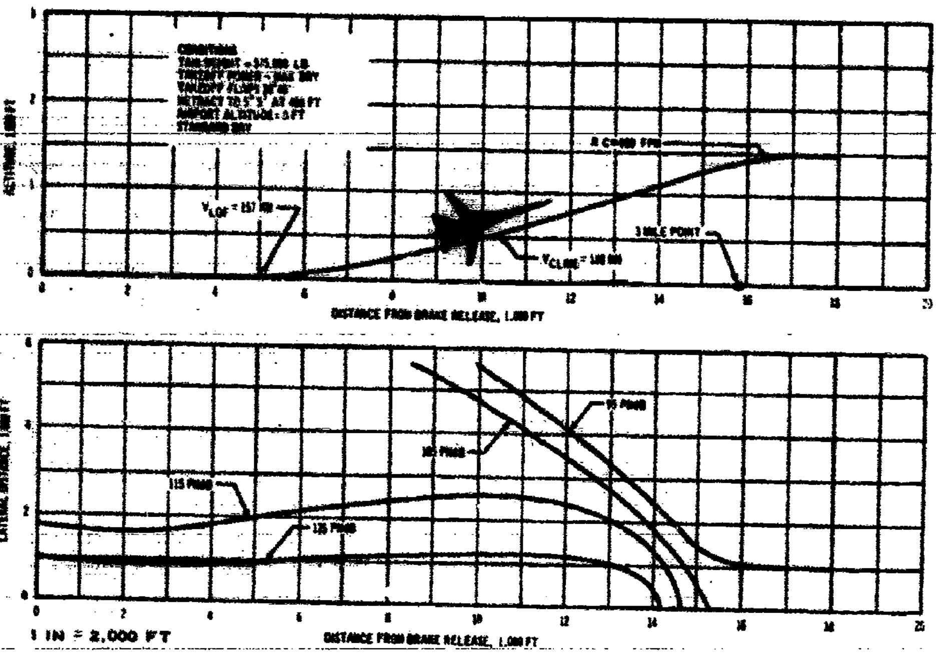


Figure 2–7. Perceived Noise Contours for Takeoff, B–2707 (GE) Domestic Mission

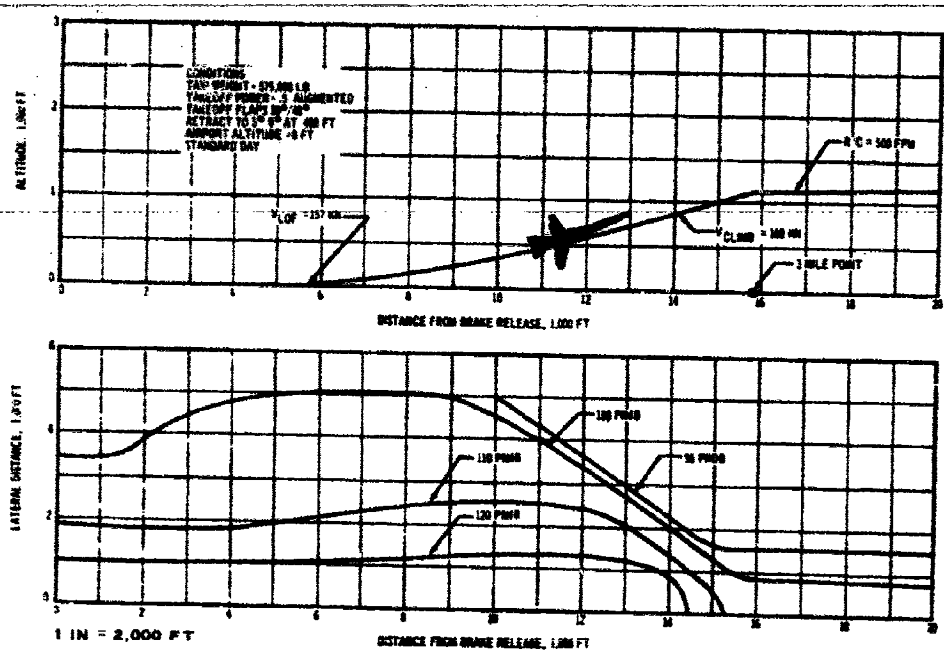
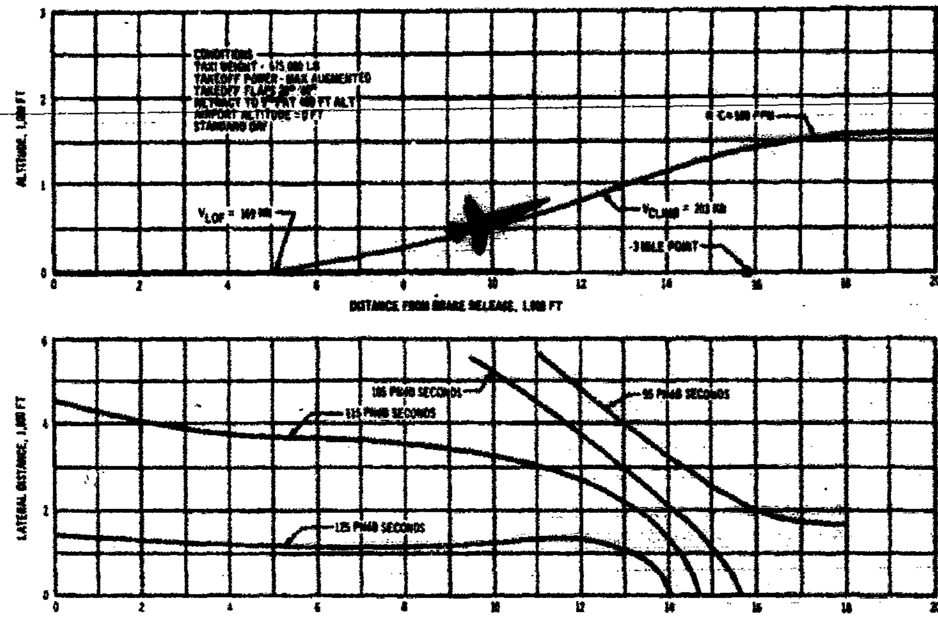
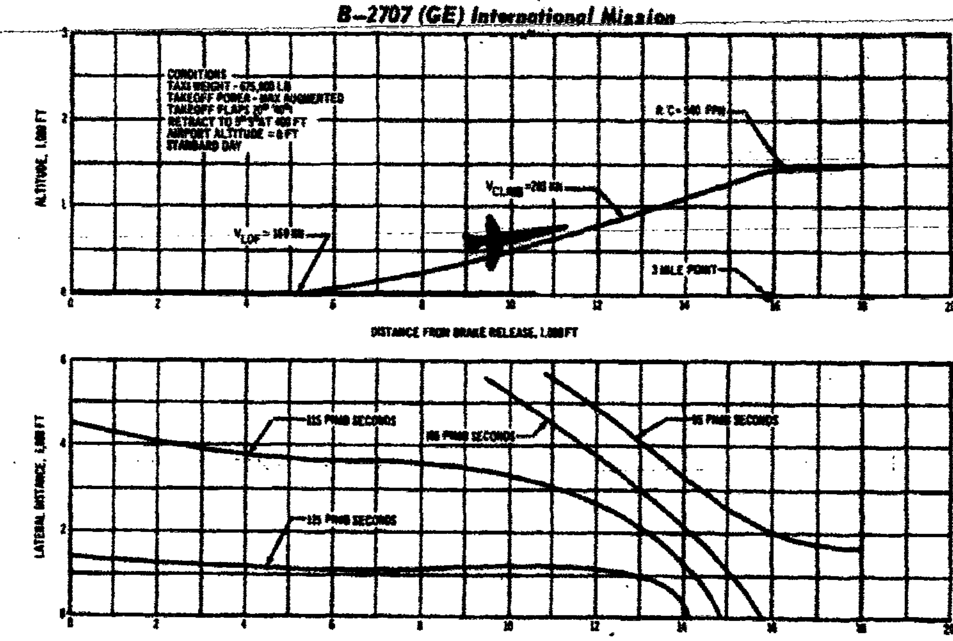


Figure 2–8. Perceived Noise Level Contours for Takeoff B–2707 (P&WA) Domestic Mission



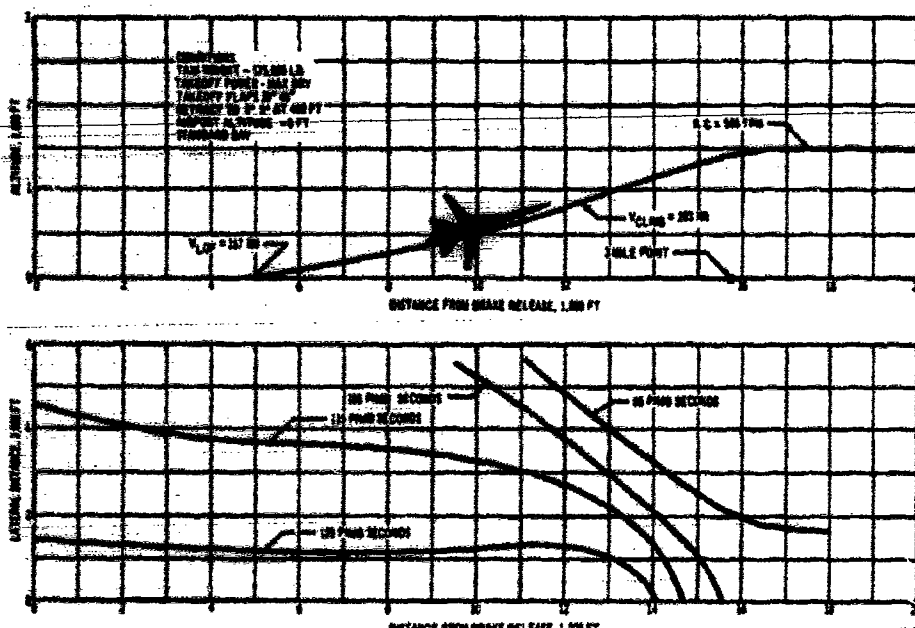
1 IN = 2,000 FT

Figure 2-9. Noise Exposure Contours for Takeoff, B-2707 (GE) International Mission



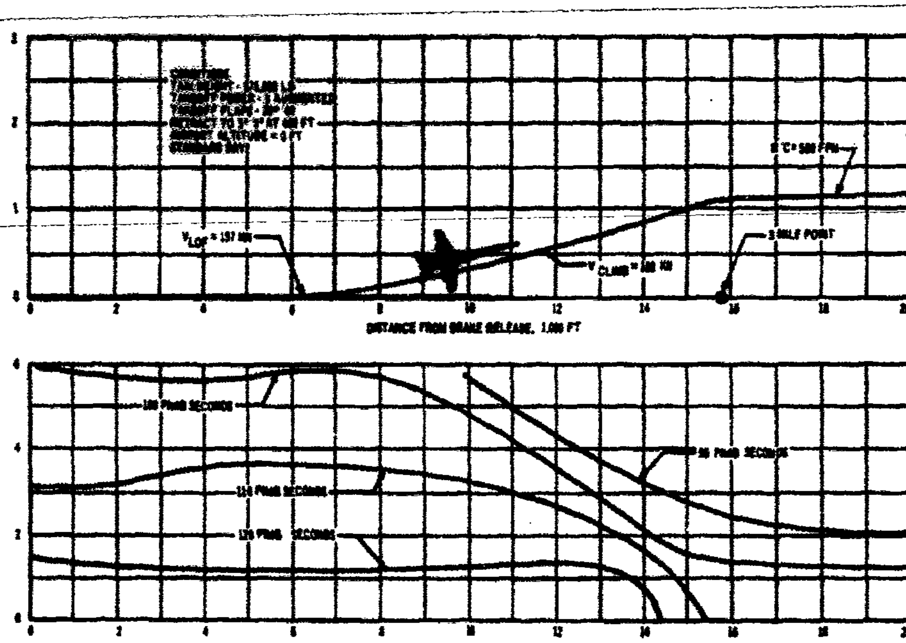
1 IN = 2,000 FT

Figure 2-10. Noise Exposure Contours for Takeoff, B-2707 (P&WA) International Mission



1 IN = 2,000 FT

Figure 2-11. Noise Contours for Takeoff, B-2707 (GE) Domestic Mission



1 IN = 2,000 FT

Figure 2-12. Noise Exposure Contours for Takeoff, B-2707 (P&WA) Domestic Mission

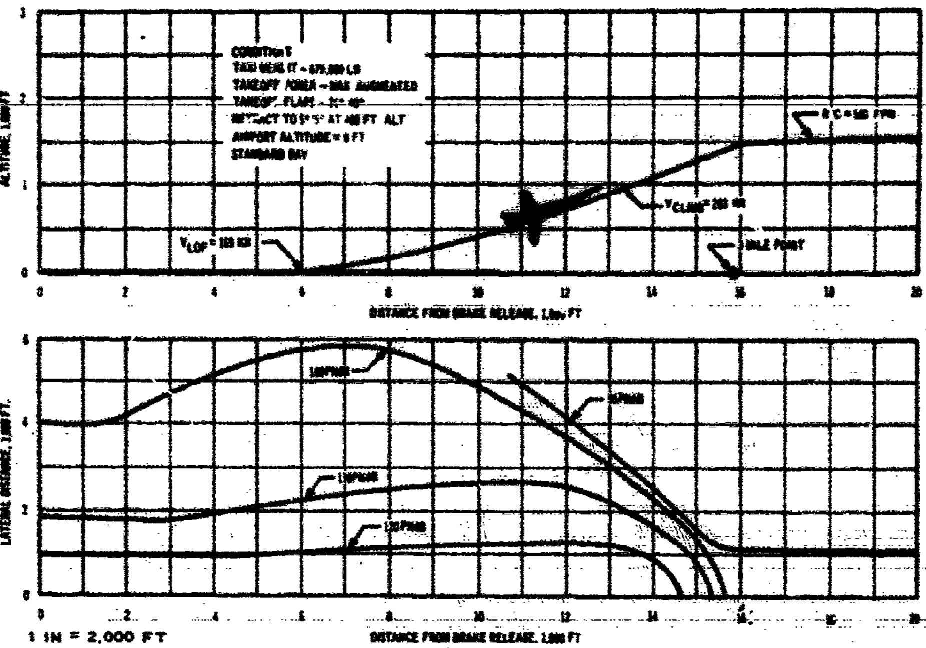


Figure 2-13. Perceived Noise Level Contours for Takeoff, B-2707 (GE) International – Boeing Jet Suppression

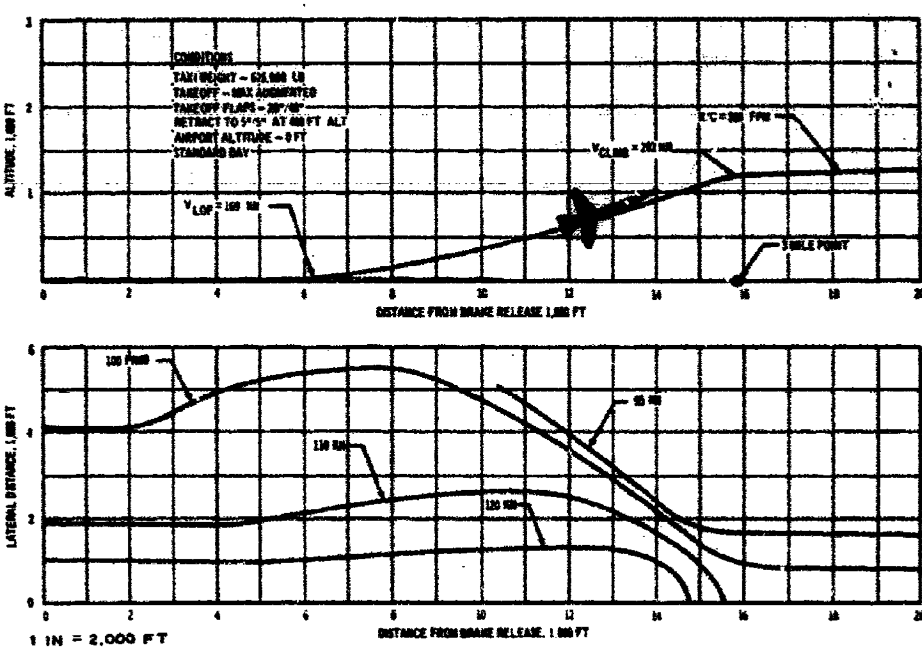
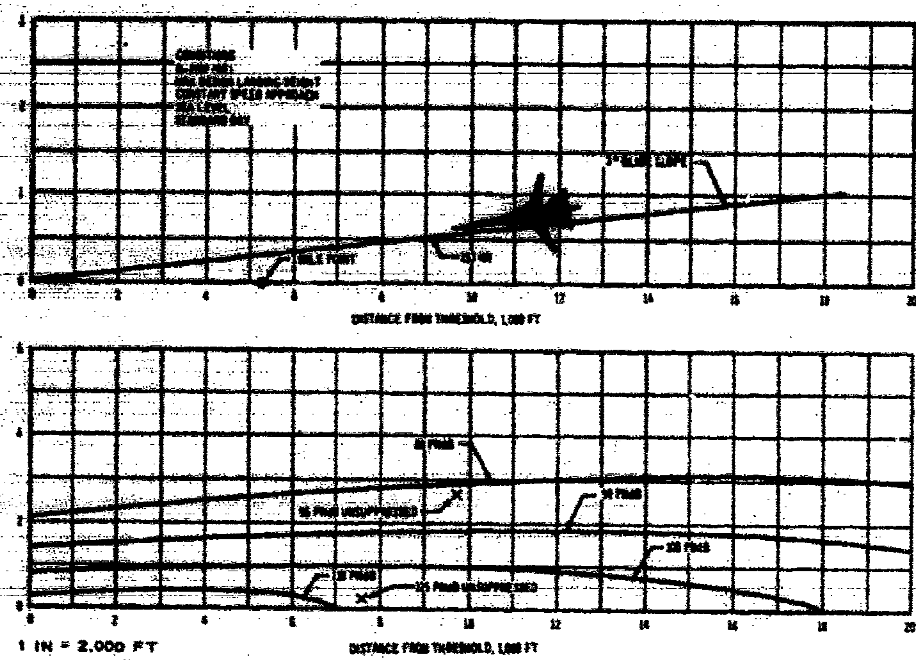
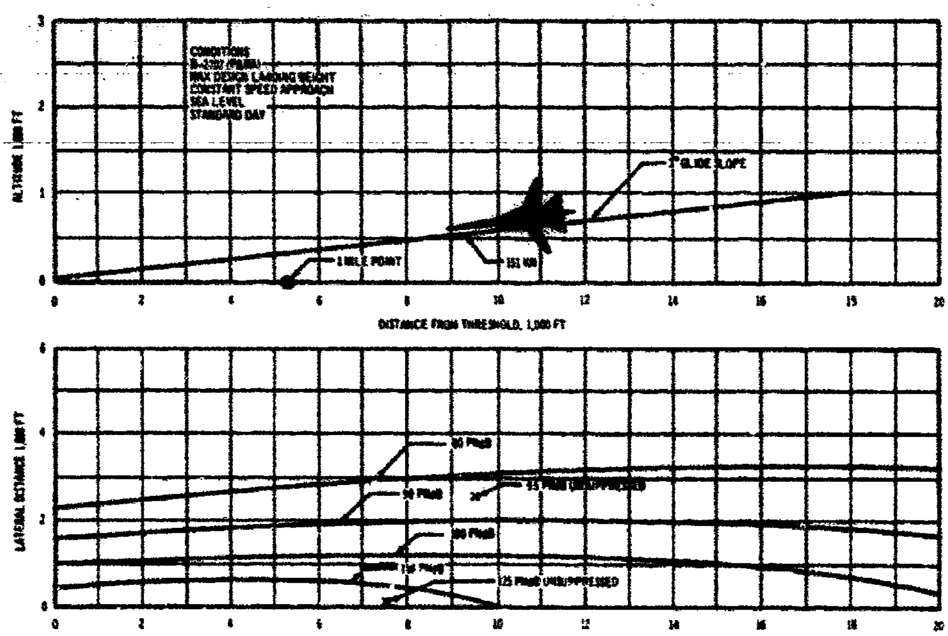


Figure 2-14. Perceived Noise Level Contours for Takeoff, B-2707 (P&WA) International – Boeing Jet Suppression



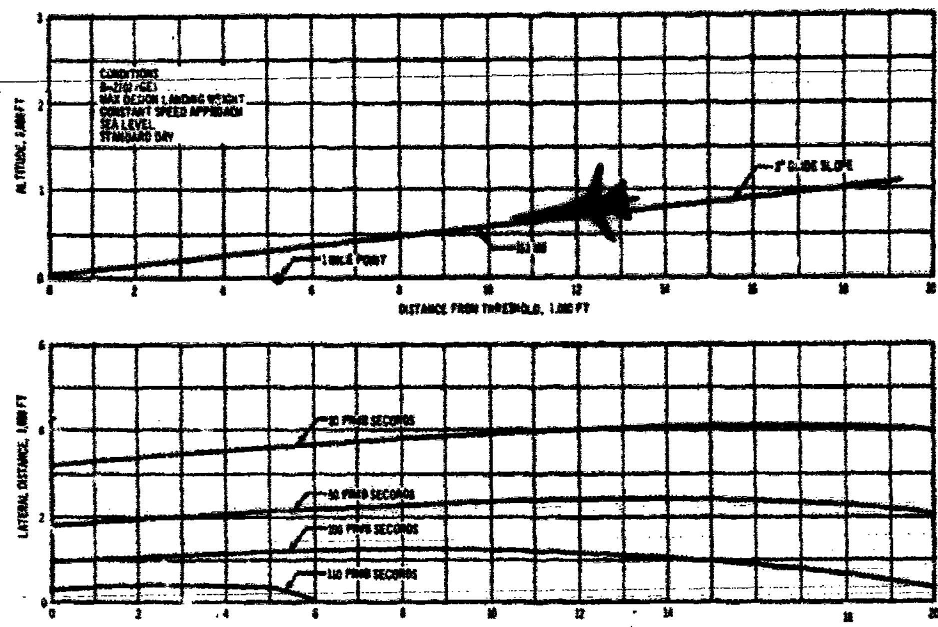
1 IN = 2,000 FT

Figure 2-15. Perceived Noise Level Contours for Landing Approach B-2707 (GE) International



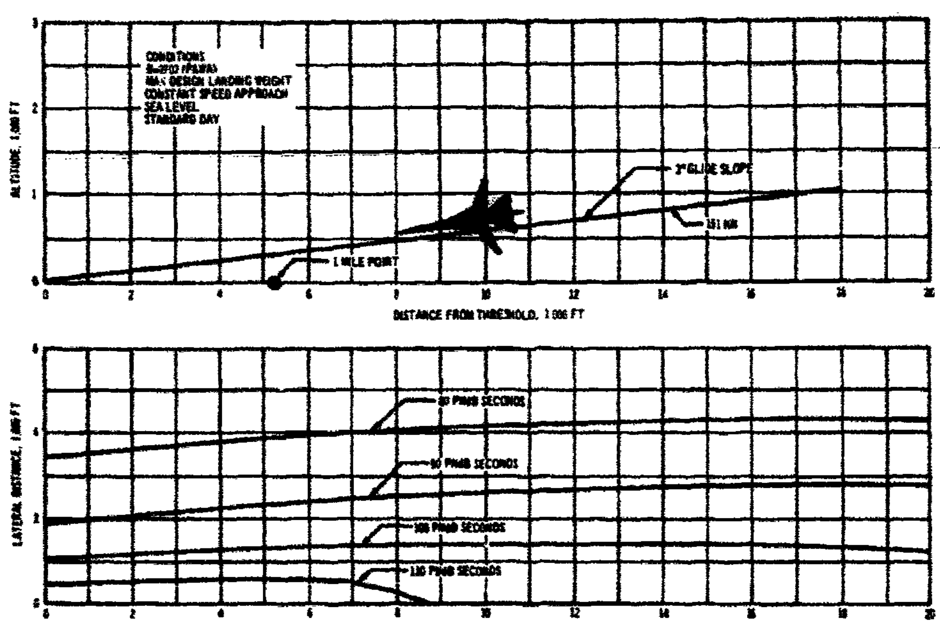
1 IN = 2,000 FT

Figure 2-16. Perceived Noise Level Contours for Landing Approach B-2707 (P&WA) Airplane



1 IN = 2,000 FT

Figure 2–17. Noise Exposure Contours for Landing Approach, for B-2707 (GE) International



1 IN = 2,000 FT

Figure 2–18. Noise Exposure Contours for Landing Approach B-2707 (P&WA) International

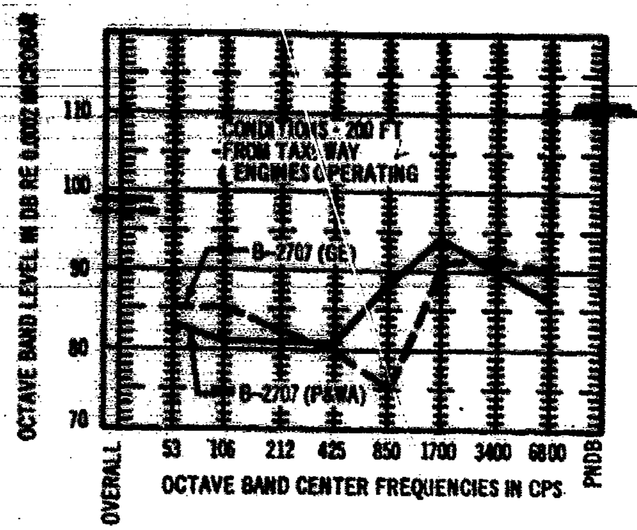


Figure 2-19. Taxi Noise Levels

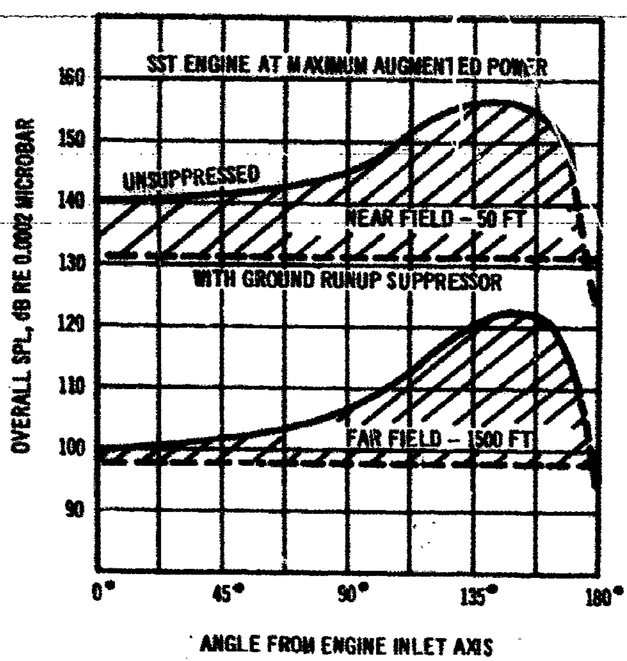


Figure 2-20. Ground Runup Noise Suppression

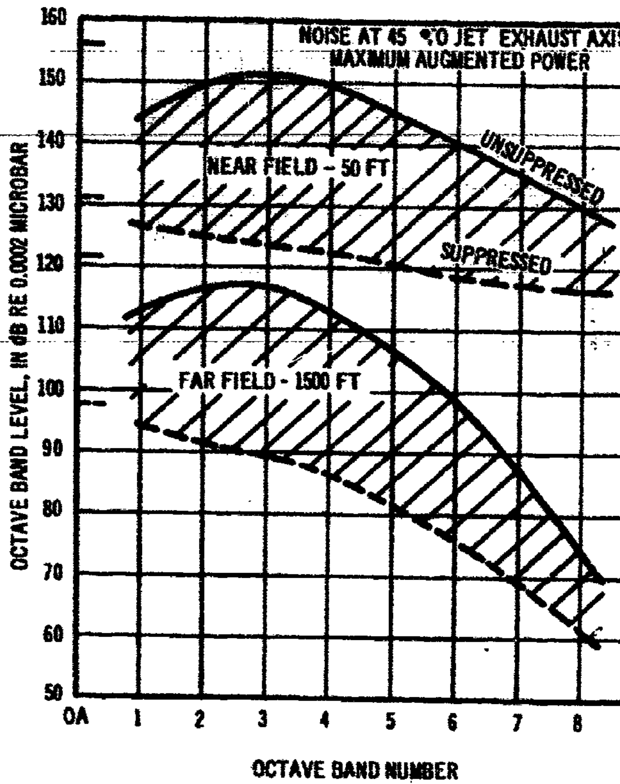


Figure 2-21. Effect Of Ground Runup Suppressor on Noise Spe

3.0 SST ENGINE NOISE CHARACTERISTICS

3.1 UNSUPPRESSED ENGINE NOISE CHARACTERISTICS

The unsuppressed noise levels predicted for the GE 4/J5P and the P&WA JTF17A-21B engines are presented in Figs. 3-1 and 3-2 for points directly beneath the flight path as a function of inflight thrust setting. Also shown are the predicted suppressed noise levels discussed in Par. 2.2. Two altitudes are shown. The 400-ft altitude is a direct result of applying the SAE noise prediction procedures. The 1,500-ft altitude noise data allows interpolation of noise levels at other flight altitudes.

Figures 3-3 and 3-4 show ground noise for points 1,500 ft to the side of the runway as a function of ground thrust setting. Tables 3-A and 3-B show noise spectra predicted for seven specific engine operations: 1) maximum augmentation, 2) maximum dry power for the GE 4/J5P, 3) 130 percent of maximum dry power for the P&WA JTF17A-21B engine, 4) noise abatement cutback thrust for the 675,000 lb International B-2707, 5) noise abatement cutback thrust for the 575,000 lb domestic B-2707, 6) landing approach thrust, and 7) taxi thrust. The engine operating conditions were chosen because of their significance in airplane operations.

The noise levels presented in Figs. 3-1 through 3-4 and Tables 3-A and 3-B have been predicted using 1) the standard SAE procedures outlined in Ref 3 for jet noise calculation and 2) the procedures outlined in Ref 4 for compressor or fan noise calculations. Figure 3-5 is a reproduction of a curve from Ref 4 showing the relationship between engine compressor or fan parameters and noise level of the fundamental discrete frequency generated by the compressor or fan. The method of Ref 4 is identical with that used by Pratt & Whitney. The General Electric method requires engine compressor data not available at Boeing.

3.2 SUPPRESSED ENGINE NOISE CHARACTERISTICS

The effects of compressor, fan, and jet noise suppression devices on predicted engine noise levels are shown in Figs. 3-1 through 3-4 and Tables 3-A and 3-B. A discussion of the means for obtaining the compressor and fan noise suppression contributing to the total PNL reductions shown are discussed in Sec 4.0 of this book.

The suppression included in Figs. 3-1 through 3-4 is the Boeing prediction for the engine and nozzles supplied by the two engine manufacturers as well as the predicted suppression for the jet suppressor Boeing will have available for the B-2707 production airplane. The inlet noise suppression achieved by use of a sonic throat in the Boeing propulsion air inlet is also included. (The increased sound suppression with the new GE, two-stage ejector nozzle is not included). This amount of suppression is consistent with the installed propulsion performance and weight used in the B-2707 performance.

3.3 ENGINE NOISE EXPOSURE CONTOURS

The noise environment around the airport and in the community during takeoff, climbout and landing approach maneuvers has been predicted for the B-2707 (GE) and B-2707 (P&WA) airplanes. This noise environment was predicted using the following procedures: Maximum noise levels at points on the ground below and to the side of the flight path were calculated according to the standard procedures in Refs 3, 4, 5, and 6. The calculation procedure assumes a gradual change in noise attenuation with distance when going from ground-to-ground propagation to air-to-ground propagation. The effect of four engines and their orientation with respect to the listener as the aircraft takes off is also included. This is done by adding 3 dB to the single engine's noise during ground roll and gradually increasing the increment to 6 dB as the airplane elevation angle increases. These transition effects are assumed to be complete by the time the angle from aircraft to listener has increased to 20 deg with respect to the ground. When several noise sources contribute to the noise level at a point on the ground, as shown schematically in Fig. 3-6 a composite spectrum is determined according to Ref 3. This composite spectrum is then used to compute the maximum perceived noise level contours corresponding to given engine parameters and flight path variations.

Table 3-A. Noise Spectra for GE 4/J5P Engine

OPERATING CONDITIONS ([illegible])	OVERALL SPL	1	2	3	4	5	6		7		8		PERCEIVED NOISE
GROUND RUNUP - 1500 FEET	(dB)	JET	JET	JET	JET	JET	JET	COMP	JET	COMP	JET	COMP	([illegible])
MAX AUG - UNSUPPRESSED	119.5	115	115	114	105	103	93	75	79	74	64	62	122.0
SUPPRESSED	118.5	112	114	113	108	102	92	75	78	74	61	62	121.0
MAX DRY - UNSUPPRESSED	117.0	110	113	112	106	100	90	75	76	74	62	62	118.0
SUPPRESSED	115.0	108	111	110	104	98	88	75	74	74	60	62	117.0
TAXI (5000# Fn) - 200 FEET													
UNSUPPRESSED	106.0	85	85	82	80	75	80T	101	85T	102	69T	100	120.5
SUPPRESSED	97.0	85	85	82	80	75	80T	91	85T	98	65T	90	111.0
FLIGHT (0.3M) - 1500 FT ALT													
MAX AUG - UNSUPPRESSED	175.5	114	119	121	119	115	108	87	95	86	77	74	130.5
SUPPRESSED	124.5	113	118	120	118	114	107	87	94	84	76	74	129.5
MAX DRY - UNSUPPRESSED	122.0	110	116	117	115	111	104	87	90	86	73	74	126.5
SUPPRESSED	120.0	108	114	115	113	109	102	87	88	86	71	74	124.5
18,500#Fn - UNSUPPRESSED	99.0	93	96	93	89	83	75	86	61	89	44	75	107.0
SUPPRESSED	98.0	92	94	93	88	82	74	61	40	60	43	90	101.0
15,700#Fn - UNSUPPRESSED	96.0	90	91	90	85	80	72	82	~8	81	41	68	105.0
SUPPRESSED	95	89	90	86	84	70	72	57	57	56	40	43	98.0
LANDING (0.23M) - 326 FT ALT													
UNSUPPRESSED	111	99	100	99	95	91	87T	102	91T	108	91T	104	125
SUPPRESSED	105	98	99	97	94	90	87T	77	91T	83	91T	79	112.5

T = Turbine Noise

Table 3-B. Noise Spectra for P&WA JTF 17A-21B

OPERATING CONDITIONS (4 ENGINES)	OVERALL SPL	1	2	3	4	5	6			7			8			PERCEIVED NOISE LEVEL
GROUND STATIC - 1500 FEET	(dB)	JET	JET	JET	JET	JET	JET	FAN EXIT	FAN INLET	JET	FAN EXIT	FAN INLET	JET	FAN EXIT	FAN INLET	(PNdB)
MAX AUG - UNSUPPRESSED	118.0	110	114	113	106	102	91	75	75	77	81	81	60	69	69	121.0
SUPPRESSED	114.0	106	110	109	104	98	87	60	75	73.5	81	81	56	69	69	117.0
130% MAX DRY - UNSUPPRESSED	114.0	107	110.5	109	104	98	88	73	75	74	81.5	81.5	52.5	69	69	117.5
SUPPRESSED	110.0	103	106.5	105	100	94	84	60	75	70	81.5	81.5	55	69	69	114.0
TAXI (5000# Fn) -200 FEET																
UNSUPPRESSED	106.5	83	81	81	81	98f	73	104	104	65	100	100	55	96	96	118.5
SUPPRESSED	98.5	83	81	81	81	98f	73	59	94	65	85	90	55	81	86	111.0
FLIGHT (0.3M) - 1500 FT ALT																
MAX AUG - UNSUPPRESSED	124.0	111	117	120	118	115	108	92	92	94	93	93	76	82	82	130.0
SUPPRESSED	120.0	107	113	115	114	111	104	77	92	90	78	93	72	67	82	127.0
130% MAX DRY - UNSUPPRESSED	122.0	109	115	118	116	113	106	92	92	92	93	93	74.5	82	82	128.0
SUPPRESSED	118.0	105	111	114	112	111	102	77	92	88	78	93	70.5	67	82	124.0
18,500# Fn - UNSUPPRESSED	101.0	93	96	96	92	88	80	92	92	66	91	91	49	79	79	112.0
SUPPRESSED	100.0	92	95	95	91	87	79	77	67	65	76	66	48	64	54	105.0
15,700# Fn - UNSUPPRESSED	98.0	92	93	91	87	81	70	87	31	55	86	86	30	74	74	110.0
SUPPRESSED	97.0	92	93	91	87	81	70	72	52	55	71	61	30	59	49	101.5
LANDING (0.23M) - 326 FT ALT																
UNSUPPRESSED	113	99	100	100	98	93	87	104	104	82	110	110	75	106	106	127.5
SUPPRESSED	106	99	100	100	98	93	87	89	80	82	95	86	75	91	82	115

f = Fan Noise

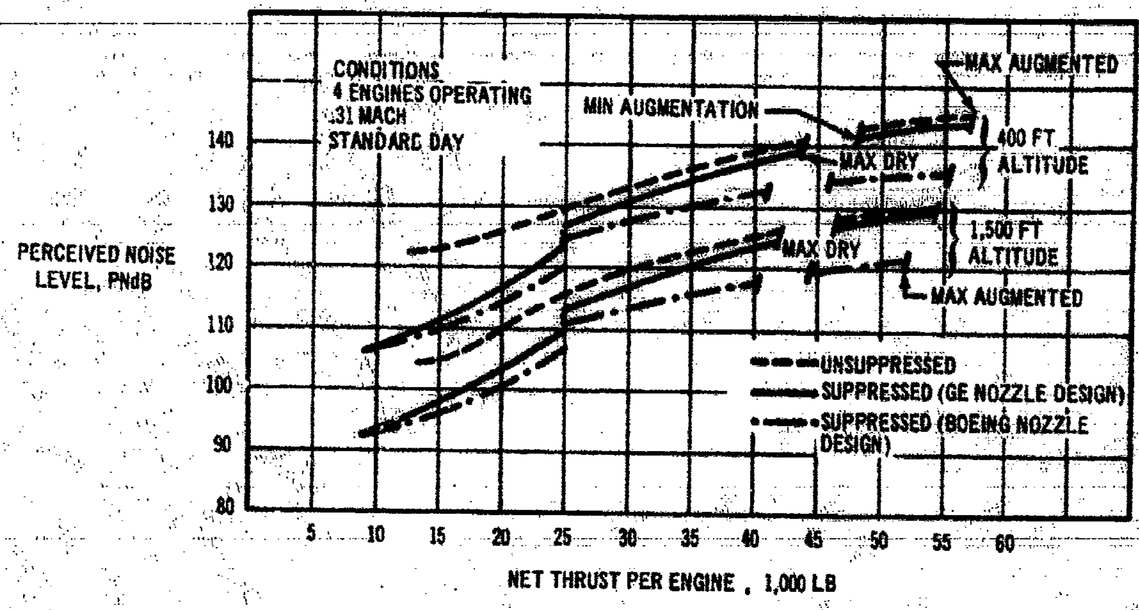


Figure 3–1. Inflight Noise Characteristics of GE 4/J5P Engine

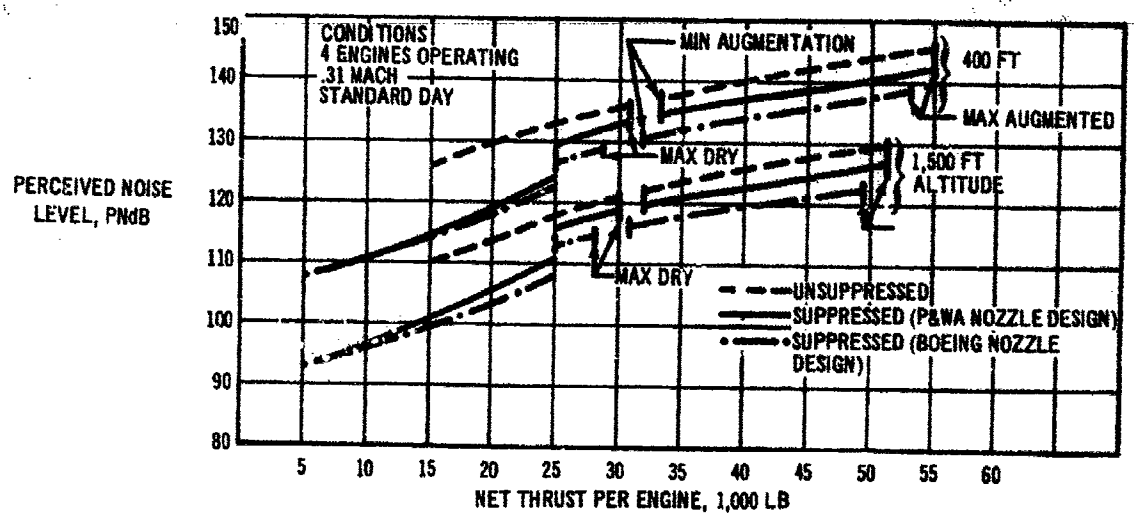


Figure 3–2. Inflight Noise Characteristics of P&WA JTF 17A – 21B Engines

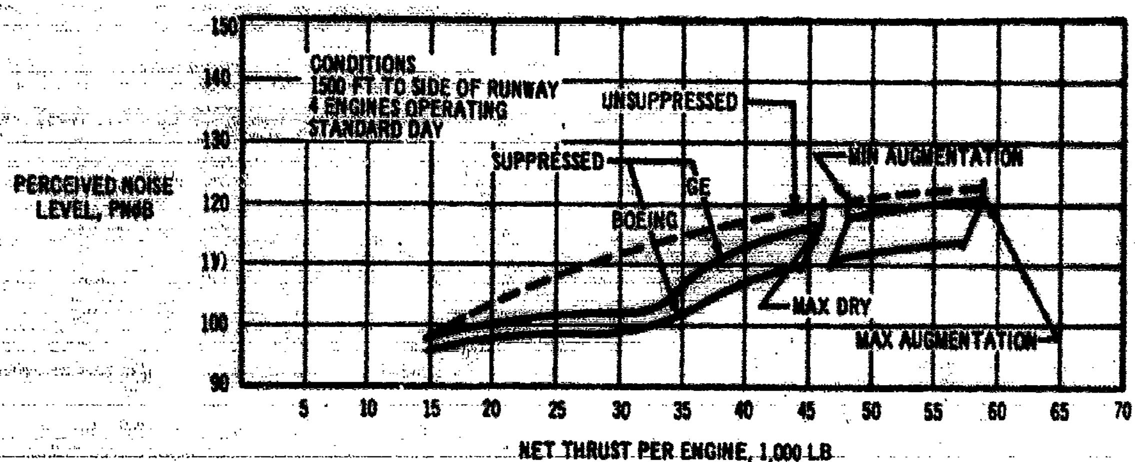


Figure 3-3. Noise Characteristics Of GE4/J5P Engines For Static Ground Operations

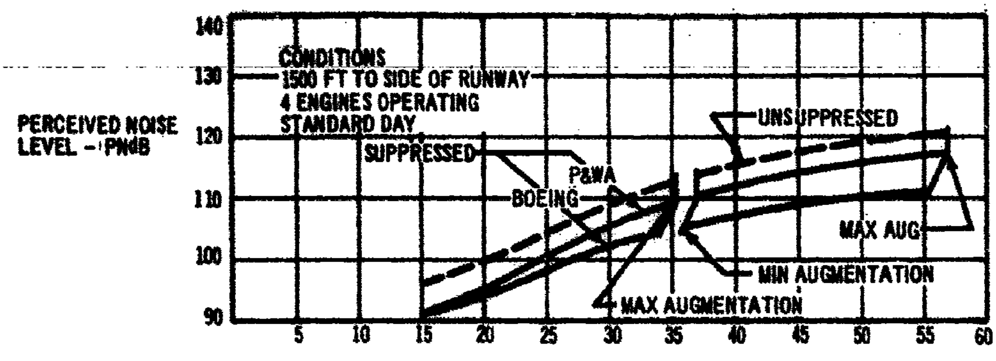


Figure 3-4. Noise Characteristics Of P&WA JTF17A-21B Engines For Static Ground Operations

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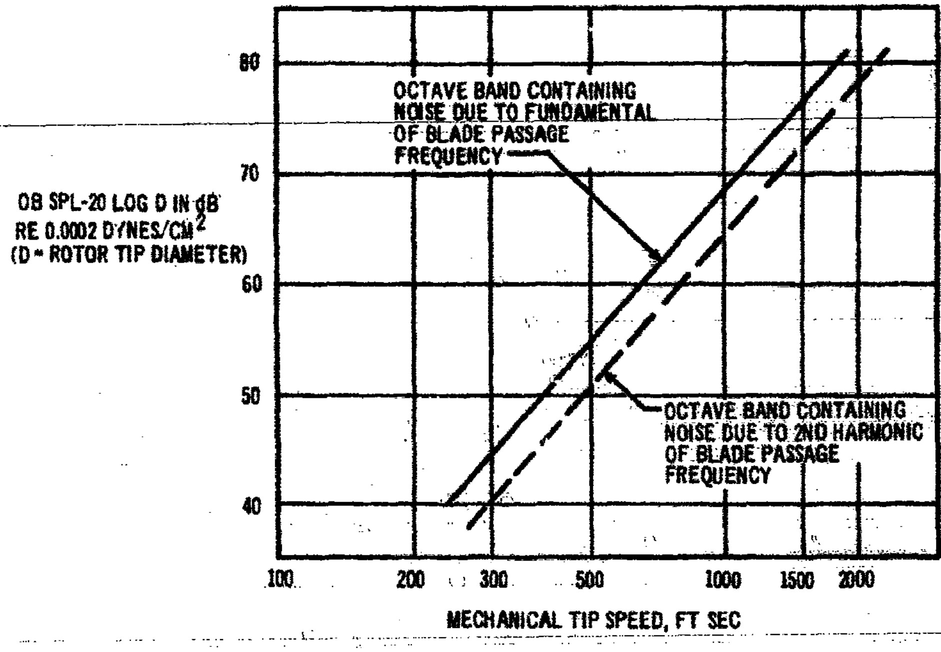


Figure 3-5. Fan and Compressor Noise Level

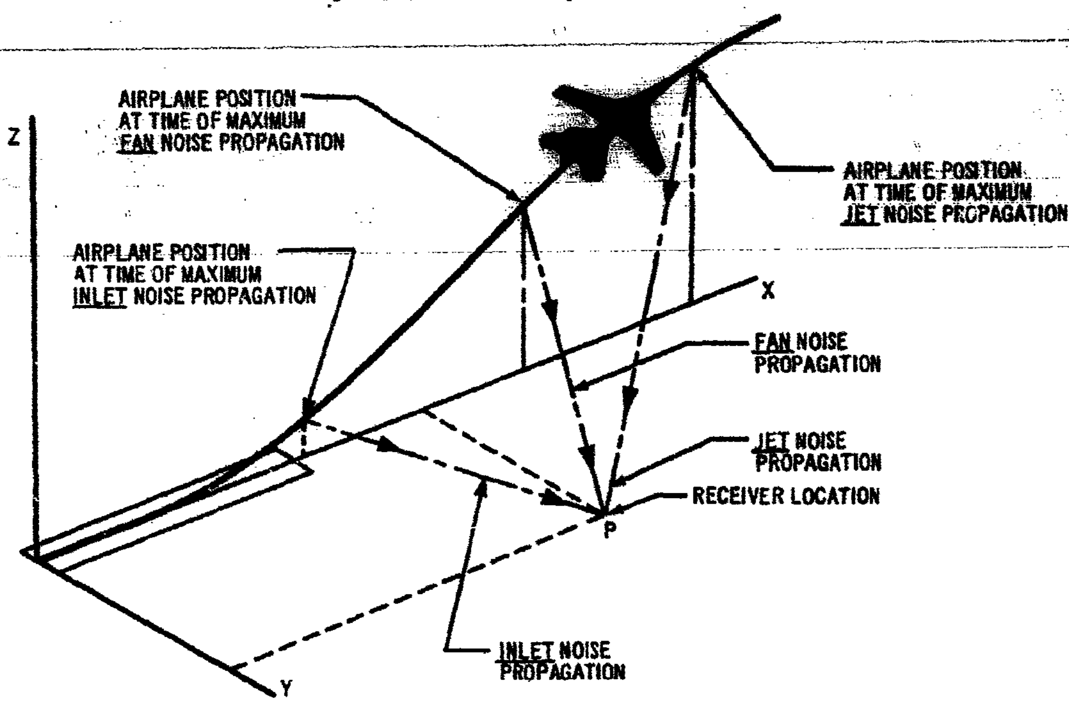


Figure 3-6. Engine Noise Propagation During Airplane Flyover

4.0 ENGINE NOISE SUPPRESSION DEVELOPMENT

The noise suppression characteristics applied to the GE 4/J5P and P&WA JTF17A-21B engines have been determined by many acoustic tests run on J-75, JT8D, and JT3D engines and on the one-eighth scale models of the exhaust nozzles of the two proposed engines. (The increased noise suppression with the new GE, two-stage nozzle ejector is not included.)

4.1 EXHAUST NOISE SUPPRESSION

4.1.1 Engine Manufacturers' Exhaust Nozzles

The exhaust noise characteristics of the GE 4/J5P and P&WA JTF17A-21B engines were determined by means of tests in the Boeing acoustic model jet facility. One-eighth scale models of the two engine exhaust nozzle configurations were built and tested at several design operating conditions, including after burning. The nozzle configurations tested are shown in Figs. 4-1 and 4-2. The noise suppression resulting from these nozzle-ejector combinations was determined from comparison with results from standard round nozzles as required by the procedures established in Ref 3. The jet noise suppression obtained with the P&WA JTF17A-21B nozzle configuration was 4 PNdB at maximum augmentation and 3 PNdB at maximum dry thrust. The jet noise suppression obtained with the GE 4/J5P nozzle configuration was 1 PNdB at maximum augmentation and 2 PNdB at maximum dry thrust condition. The jet noise suppression Boeing has used to predict the suppressed noise levels of the B-2707 airplane is shown in Fig. 4-3. The suppression for the August submittal by General Electric with the new two-stage ejector nozzle, may be found in the Appendix. Further discussion of engine manufacturers' suppression objectives may be found in Engine Airframe Technical Agreement, D6A10193-1 (GE), and D6A10199-1 (P&WA).

4.1.2 Boeing Exhaust Nozzles

In addition to the noise suppression studies carried out on the nozzle-ejector combinations offered by the engine manufacturers, Boeing has also conducted an intensive noise suppression research and development program to define methods of further improving the noise characteristics of the B-2707 with either of the offered engines. This program, based on 15 years of noise suppression research and development, has yielded significant new information for suppression of augmented propulsion systems.

A number of jet wake noise suppression configurations have been studied and have been tested model scale. One configuration tested yields up to 8 PNdB reduction. This configuration can be installed in the divergent portion of the ejector shroud of the exhaust nozzle. The reduction in airport-community noise exposure afforded by this suppressor is shown in Figs. 4-4 and 4-5. Pictures of the scale model suppressor configurations adapted to the GE4/J5P and P&WA JTF17A-21B engines are shown in Figs. 4-6 and 4-7. The suppression characteristics of this suppressor are given in Figs. 4-8 and 4-9.

More advanced suppression concepts developed by Boeing have demonstrated the potential to reduce noise levels by as much as 15 to 20 PNdB. Suppressors incorporating these concepts will require more extensive treatment of the primary engine and nozzle system. This study is being conducted in a company-funded research program. Figures 4-4 and 4-5 show the reductions in airport and community noise levels that would result from use of such suppressors.

As a result of the above suppression studies, Boeing feels that a jet suppressor yielding 10 PNdB suppression at maximum augmented thrust on the GE Turbojet and 8 PNdB on the P&WA turbofan, is feasible for the B-2707 production airplane. Boeing will work closely with the engine contractor to develop this suppressor and insure its compatability with the engine-airplane configuration. The predicted airport and community noise reduction for this suppressor is also illustrated on Fig. 4-4 and 4-5. Adjustments in thrust and weight have been included in the performance of the B-2707 in order to determine the correct altitudes and thrust for noise prediction in the community.

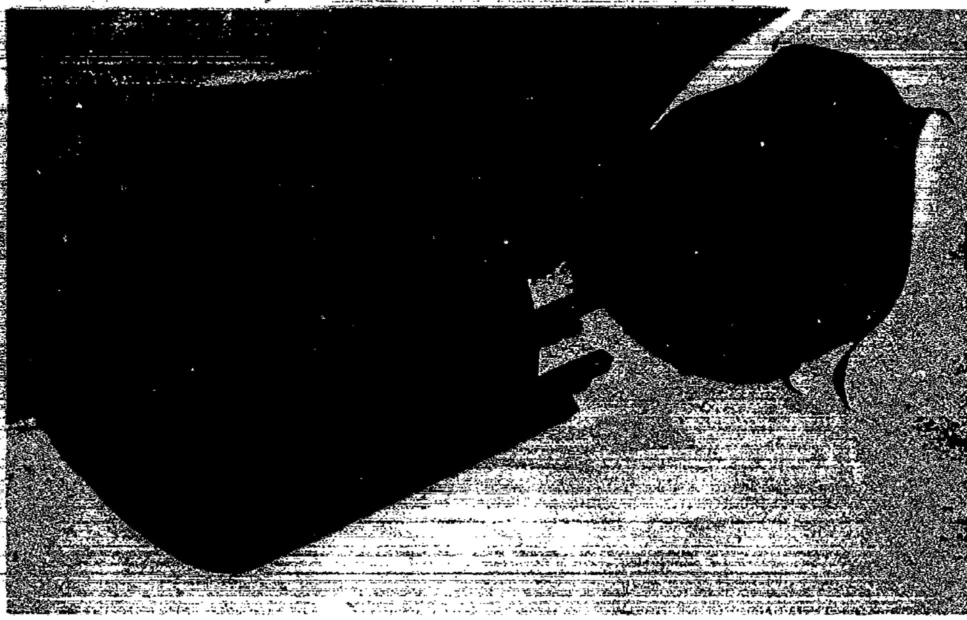


Figure 4-1 GE 4/J5P Model Nozzle Configuration

Figure 4-2. P&WA JTF 17A – 21B Model Nozzle Configuration

Propulsion Report, V2-2707-12, and Refs 7 and 8 contain a more detailed report of the Boeing noise suppression program.

4.2 COMPRESSOR NOISE SUPPRESSION

Inlet noise suppression on the B-2707 is accomplished by producing a sonic throat in the inlet during operations in which compressor or fan noise radiating from the inlet is likely to contribute to the overall noise level. The sonic throat is obtained by expanding the centerbody to a point where air flow through the inlet reaches sonic velocity. Boeing has demonstrated the compressor noise suppression afforded through application of the sonic throat principle in the inlet of a J-75 turbojet engine (Fig. 4-10 and Ref. 9). In this test the J-75 was fitted with a SST-type inlet complete with simulated expanded centerbody. The effect of the sonic throat on the discrete frequency compressor noise generated by the J-75 engine is shown in Fig. 4-11. Predicted unsuppressed GE4/J5P and P&WA JTF17A-21B inlet noise spectra has been superimposed on the J-75 spectra to indicate the predicted change in noise level between the SST engines and the J-75. Elimination of the discrete frequency spikes present in the SST engine spectra will result in a possible 30-dB reduction in the peak noise level.

Additional testing has been conducted at Boeing on a 5-in. diameter model inlet to examine near sonic as well as sonic conditions under both simulated flight and static conditions. Figure 4-12 shows the effect of inlet mach number on the suppression as determined from this test. The sonic condition shows a reduction in noise level of 40 dB. Simulated airplane speed had no measurable effect on the suppression achieved by the sonic throat. A detailed report of the test and the results may be found in Ref 2.

4.3 FAN NOISE SUPPRESSION

The noise generated in the fan section of a turbofan engine and propagated rearward through the fan discharge duct has the same noise intensity as that propagated forward through the inlet. Suppression of this noise is therefore essential if substantial total noise reduction is to be achieved.

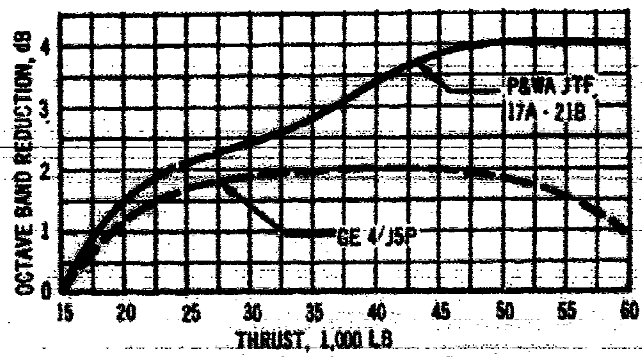


Figure 4-3. Predicted Jet Noise Suppression

Boeing has conducted tests on fan engines to determine the feasibility of acoustically treating fan discharge ducts to attenuate discrete frequency noise. Results of tests on a JT8D engine (Fig. 4-13) show large attenuations of discrete frequencies. As much as 20-dB reduction was obtained with 50 in. of treatment on one side of the duct (Fig. 4-14). A more detailed report of the test and the results may be found in Ref. 10.

Subsequent tests, made on a JT3D engine with lined fan discharge ducts, showed substantial attenuation due to the liner (Fig. 4-15 and Ref. 11).

It would appear from these tests that discrete frequency noise from the fan can be attenuated 10 to 15 dB by use of acoustical absorptive material fitted within the present design of the JTF17A-21B engine. Additional suppression should also be possible through proper fan design.

Pratt and Whitney has guaranteed a 15 dB reduction from the predicted fan discharge noise levels produced by the unsuppressed JTF17A-21B engine. It is expected that this suppression will be achieved by (1) proper fan design for minimum noise generation and (2) acoustic treatment of the fan discharge duct wall to attenuate the discrete frequency fan noise as it is propagated through the duct. This reduction has been used in the calculation of the B-2707 (P&WA) airplane noise levels.

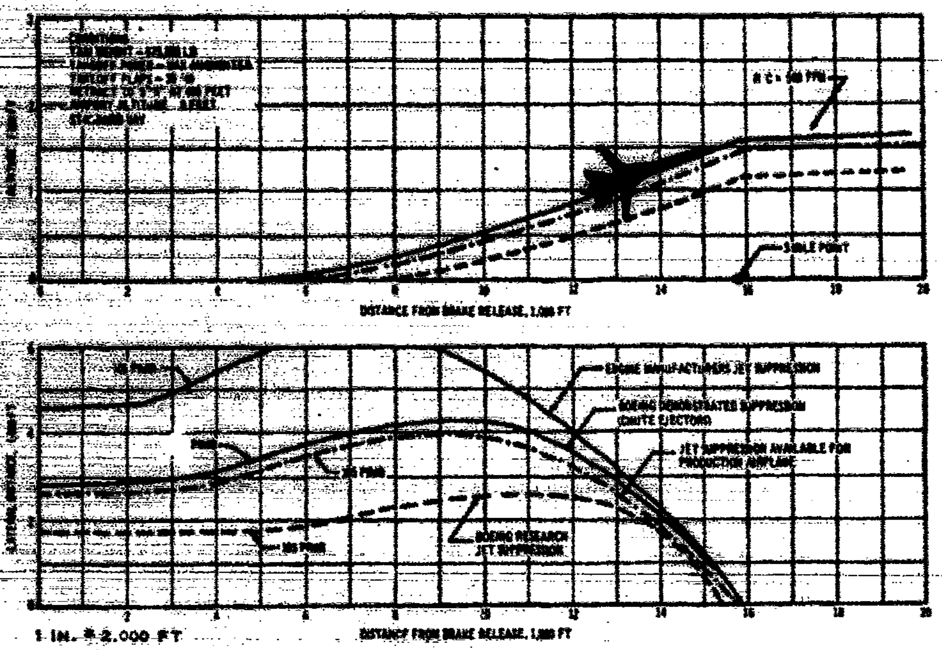


Figure 4-4. Effect of Jet Suppressors on Airport – Community Noise Exposure B-2707 (GE) International Mission

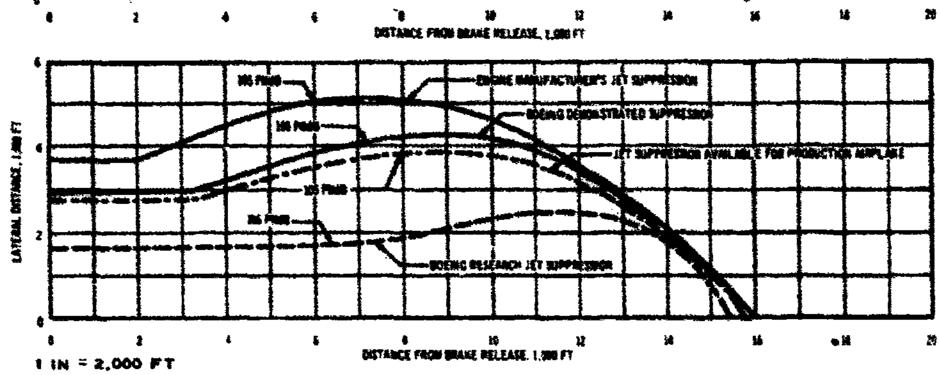


Figure 4-5. Effect of Jet Suppressors on Airport – Community Noise Exposure for B-2707 (P&WA) International Mission

Figure 4-6. Boeing Jet Suppressor, Turbojet Scale Model

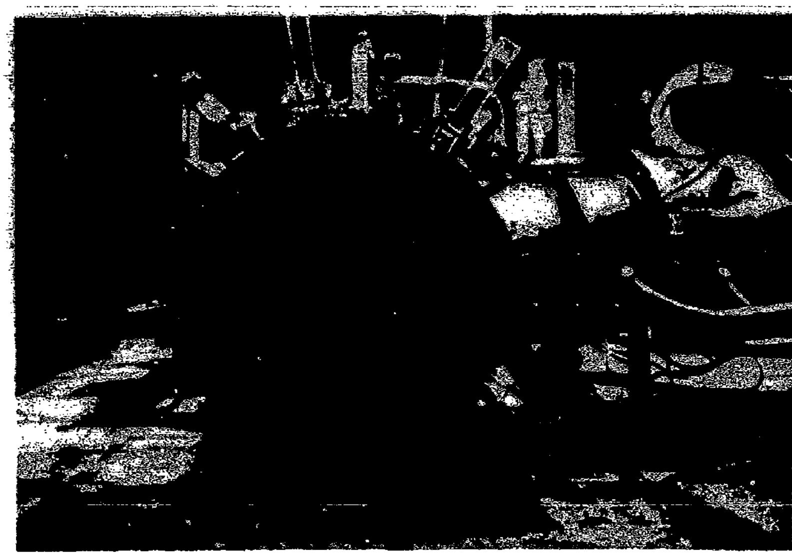


Figure 4.7. Boeing Jet Suppressor, Turbofan Scale Model

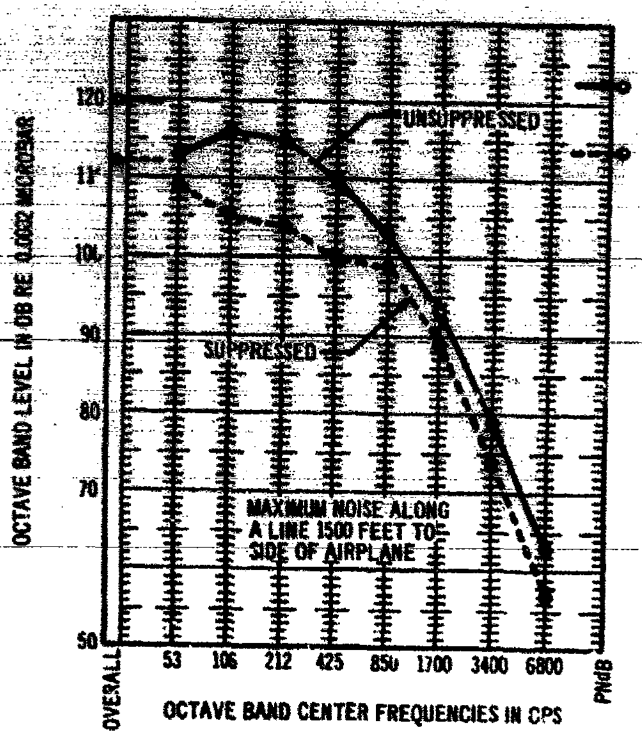


Figure 4-8. Boeing Jet Noise Suppression For Turbojet Engine

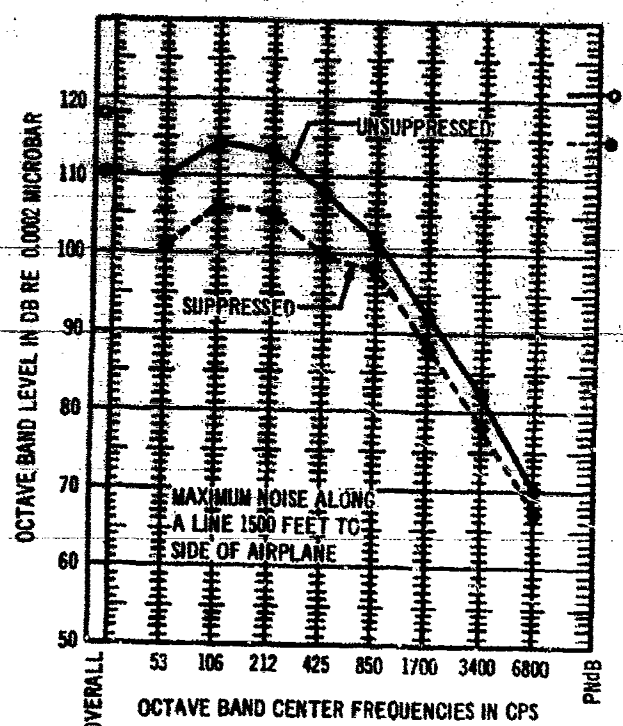
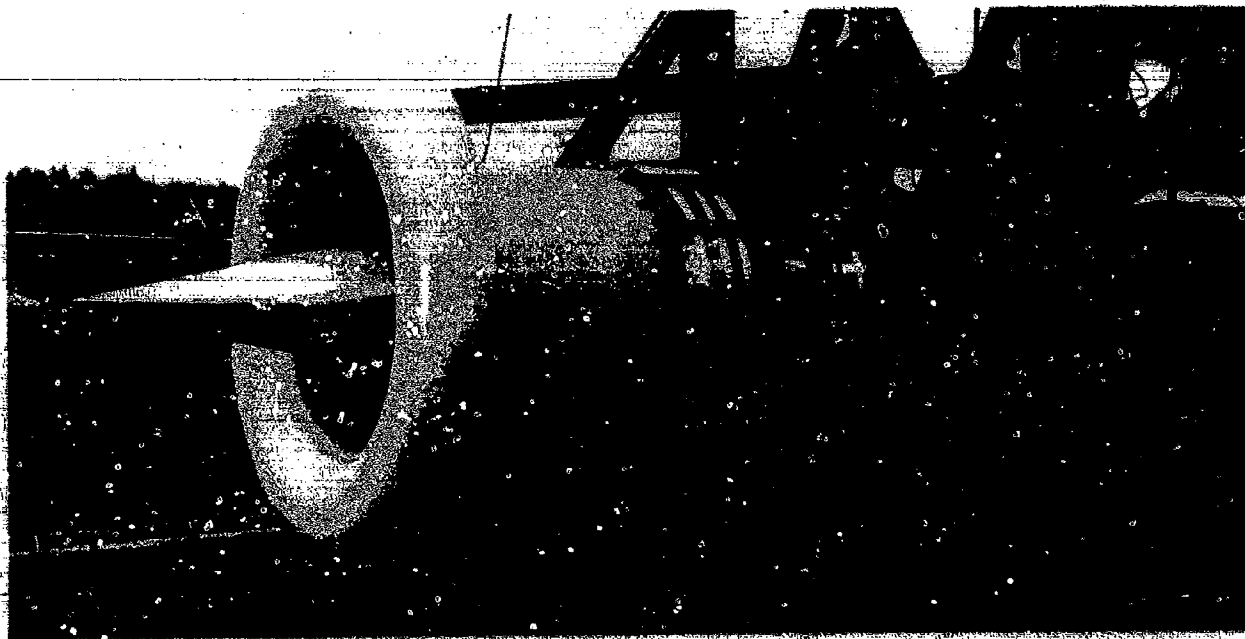


Figure 4-9. Boeing Jet Noise Suppression For Turbofan Engine



1-A COMPLETE INSTALLATION WITH BELLMOUTH

1-B BELLMOUTH REMOVED SHOWING EXPANDED POSITION SPIKE

Figure 4-10 J-75 Installation For Acoustic Evaluation of Sonic Throat

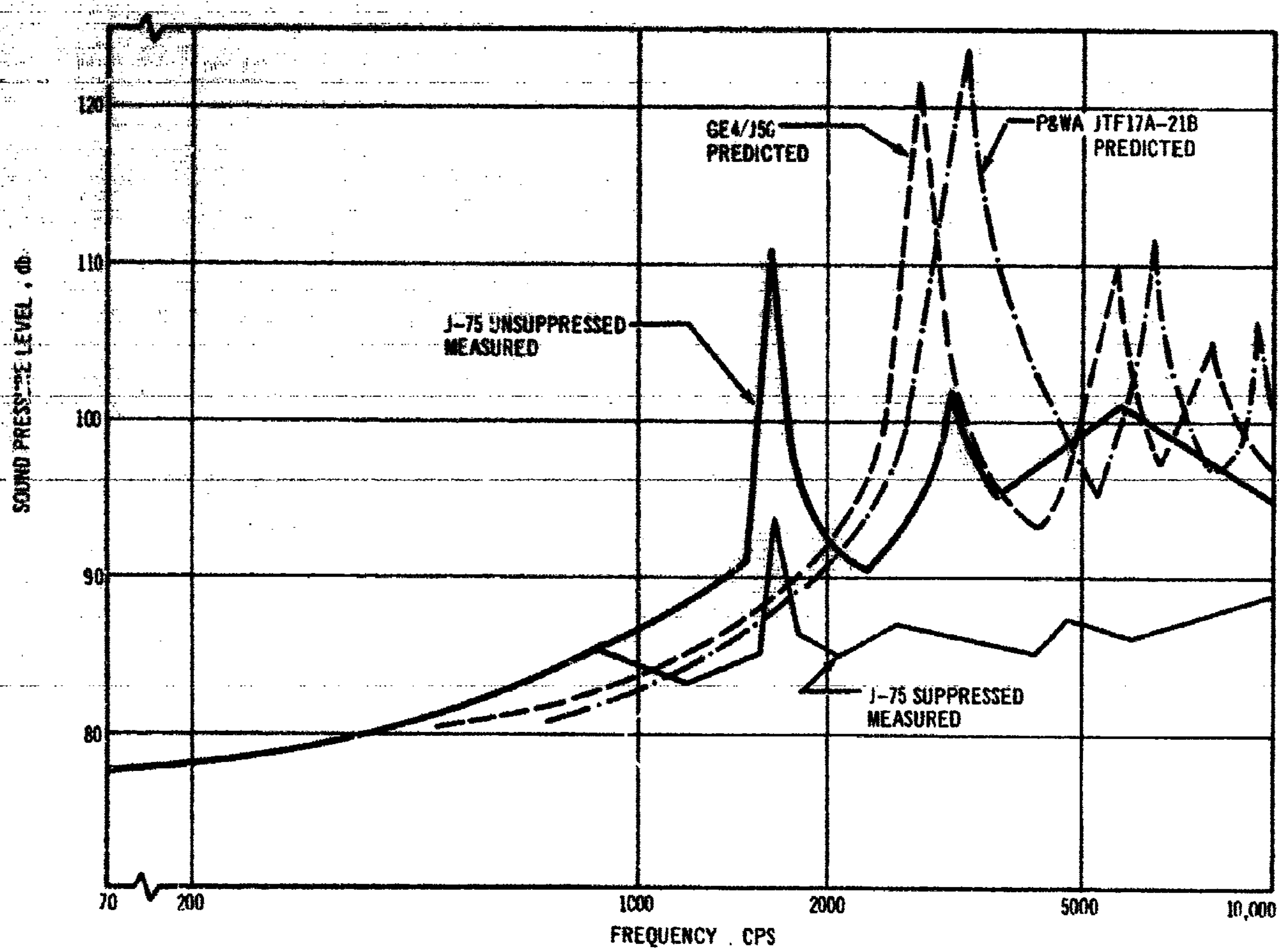


Figure 4-11. Effect of Sonic Throat on Discrete Frequency Compressor Noise Propagation

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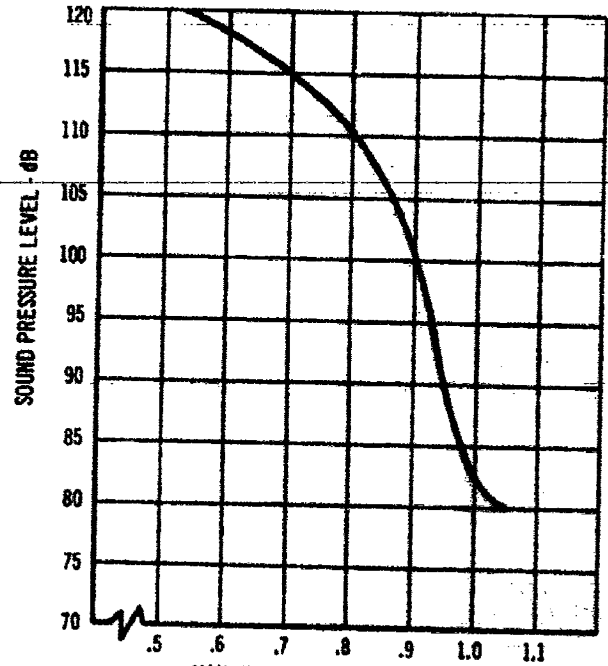


Figure 4–12. Effect of Inlet Mach. No. on Compressor Discrete Frequency Noise

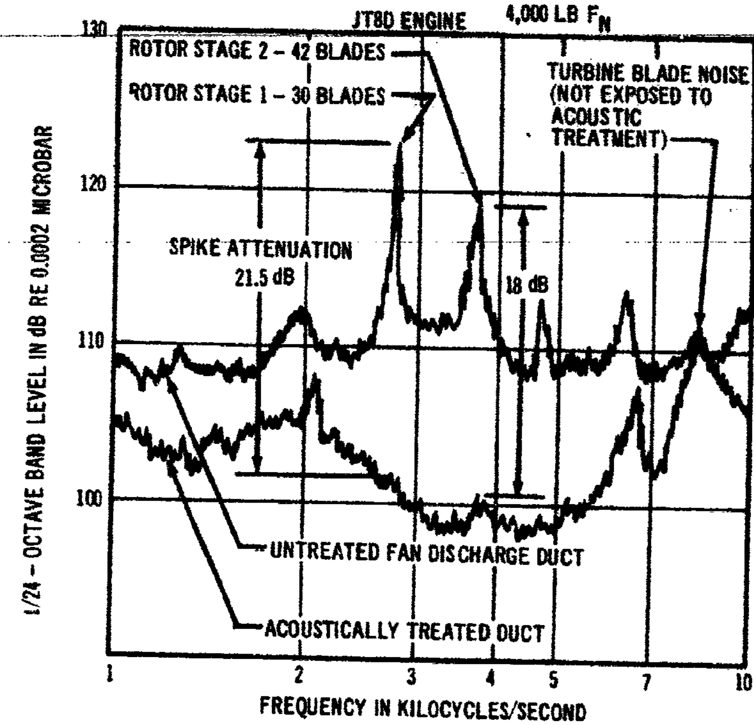


Figure 4–13. JT8D Fan Discharge Noise Suppression

V4-B2707-4

2–A OUTER COWLING REMOVED

2–B OUTER COWLING IN PLACE

Figure 4-14· JT8D Turbofan Engine With Acoustically Treated Extension To Fan Duct

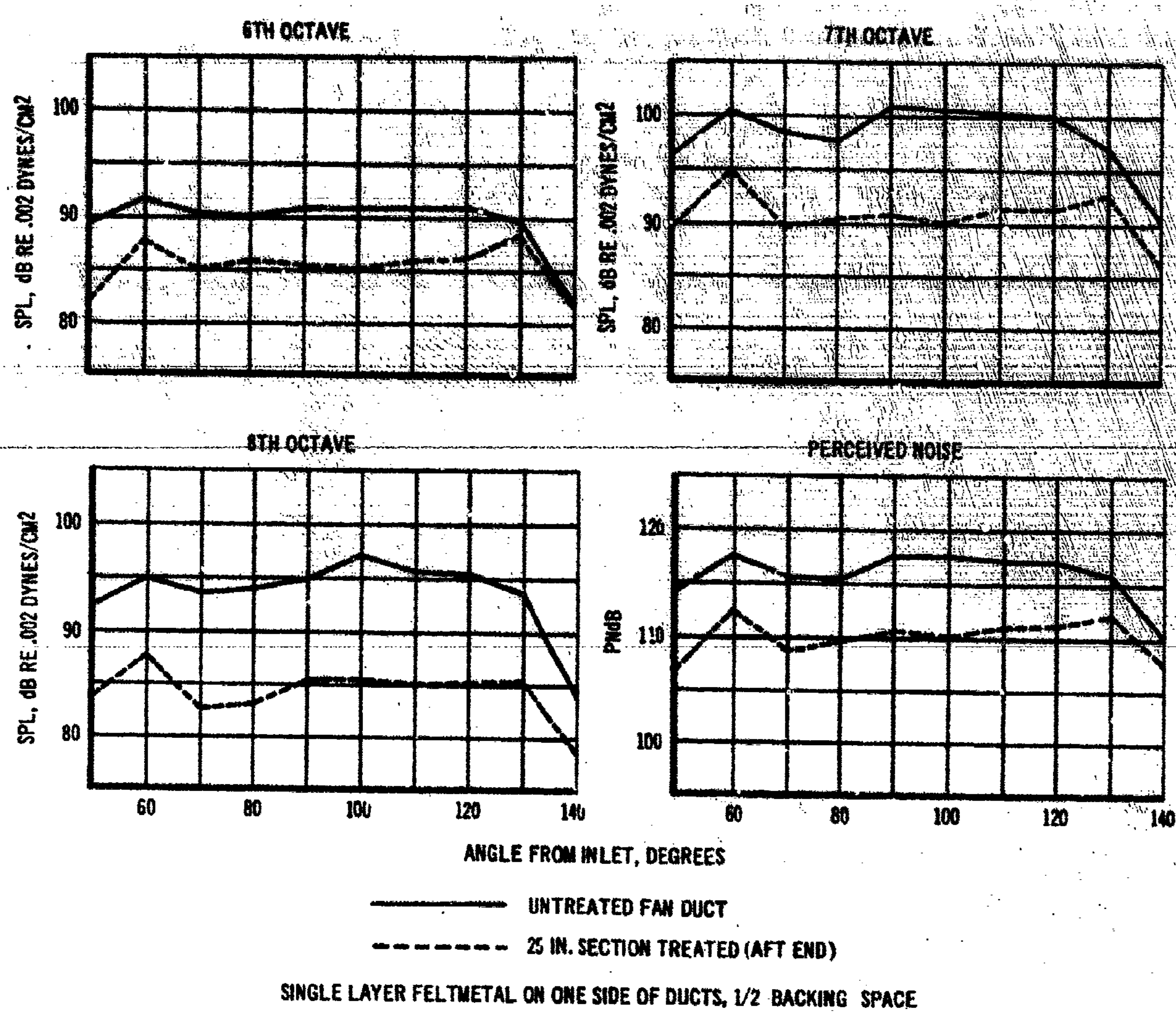


Figure 4-15. JT3D Fan Discharge Noise Suppression

5.0 ACTIVITIES PLAN

The airport and community noise activities plan has as its objective the acceptance of the B-2707 into its airport environment from a noise standpoint. To achieve this objective the activities plan includes:

a. Continuation of compressor, fan, and jet noise supression studies.

b. Evaluation of suppression techniques proposed by the engine contractor.

c. Evaluation of engine noise data supplied by the engine contractor.

d. Application of proven suppression techniques to the SST.

e. Analysis of noise from the Prototype and Production Engines.

f. Analysis of noise from inflight operations of the Prototype and Production Airplane.

g. Development and evaluation of noise contours for airports.

h. Examination of methods of airplane operation to reduce noise levels.

i. Examination of the human response to aircraft noise.

The responsibility for these activities is assigned to the Acoustics Unit of the Electrodynamics Staff reporting to the Chief of SST, Technology, Boeing SST Division, with support from the Propulsion Staff, the Aerodynamics Staff, and Flight Test. (Refer to Program Management, V5-B2707-8.) The airport and community noise activities plan will be executed in accordance with the program schedule shown in Fig. 5-1.

Further work plans are contained in the Detail Work Plan, V5-B2707-4. Control of the program will be maintained through the use of detailed and summary PERT networks and periodic status reporting. These activities are consistent with Integrated Test Program, V4-B2707-11.

5.1 NOISE SUPPRESSION DEVELOPMENT

Boeing's noise suppression development will be continuous through Phases III, IV, and V to ensure airport compatibility of all versions of the B-2707 with all airports from which it will operate.

5.1.1 Jet Noise Suppression

Jet noise suppression will include analysis of jet noise generation and suppression. Model and full scale testing of various nozzle and ejector shapes will be conducted. The objective of these studies will be to establish suppressor optimization rules by which suppressors can be designed to give maximum sound reduction for the least thrust loss and weight penalty. This effort will be integrated with the engine contractor's studies to obtain the optimum jet suppression on the engine.

5.1.2 Compressor Noise Suppression

Compressor noise suppression studies will be directed primarily to the optimization of suppression through control of airflow through the inlet. Sonic and near sonic flow conditions created through expansion of the inlet centerbody will be examined to assure maximum compressor inlet noise attenuation for all ground and flight operations.

5.1.3 Fan Noise Suppression

Fan noise suppression studies will include inlet airflow control investigations as described in Par. 5.1.2 with additional studies on suppression of discrete frequency noise generated by the fan and propagated down the fan discharge duct. Absorptive studies will continue in conjunction with the engine contractor's noise studies to help design absorptive linings and acoustic impedance mismatch devices for reducing downstream noise propagation.

5.2 AIRPORT NOISE STUDY

The airport noise study currently being conducted will be expanded to include other airports, both domestic and foreign. B-2707 engine-airplane noise characteristics will be monitored continuously. The pattern of noise complaints in airplane-noise sensitive areas near airports will be studied. Methods of reducing the noise problems through noise suppression and noise abatement techniques

on the engine and airplane will be investigated. These methods will be recommended to the FAA, the airlines, and the airport operators when their use could result in alleviation of noise. Airport and community noise report will be prepared in accordance with the data list.

5.3 SUBJECTIVE REACTION PROGRAM

A current Boeing research program to study the subjective effects of noise is divided into three concurrent efforts:

a. Studies of psycho-acoustical perception and scaling, Emphasis is on the relationship between subject judgements and the physical variables of sounds (e.g. octave band spectrum, discrete frequency components, duration, and doppler effects).

b. Examination of jet aircraft noise as potential interference with present modes of living and working. These studies will explore the effects of noise on sleeping, reading, communications, concentration, task performance etc.

c. Derivation of relationships between community complaints and past aircraft noise exposures. These studies will identify significant correlation between aircraft type, flight procedures, noise characteristics, weather, season, time of day, airport topography, etc., and relevent community complaint data.

5.4 TEST SCHEDULE

The test schedule planned to ensure B-2707 compliance with airport and community noise guarantee includes:

a. Tests on model scale jets to develop jet noise suppressors.

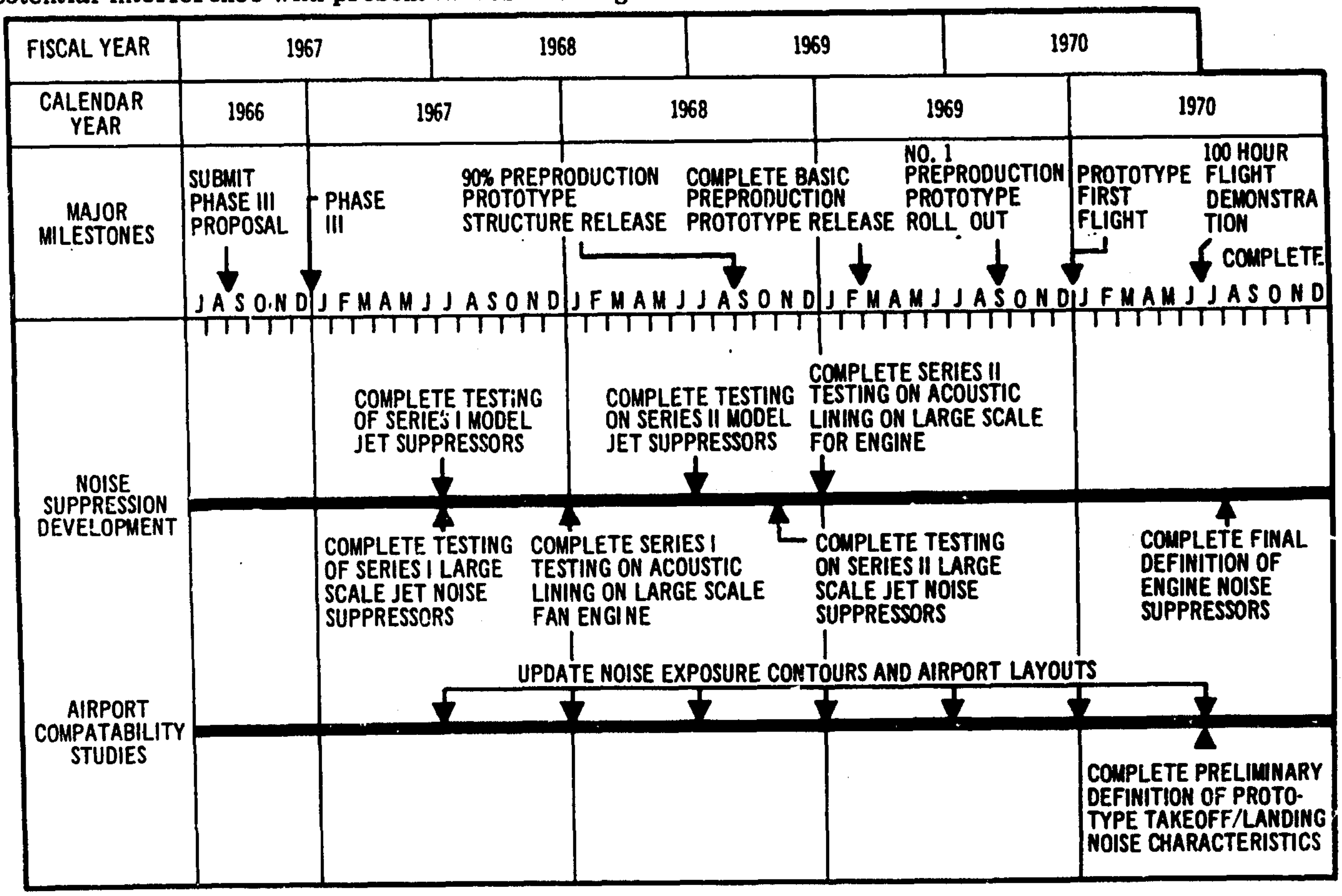


Figure 5-1. Program Schedule

b. Ground Tests on large scale and full scale engines to provide verification of model scale test results.

c. Large scale tests of the sonic throat principle.

d. Large scale tests of fan discharge acoustic liners for discrete frequency attenuation.

e. Flight tests to ensure adequate noise suppression of selected noise suppression devices during low-speed flight operations.

Technical knowledge gained by the Boeing Company in making community noise measurements of its family of jet transports will be utilized in establishing procedures for testing and for data analysis of the B-2707.

The prototype will be used to determine the ground and flight noise characteristics of the B-2707 engine-airplane configurations with noise suppression devices developed to that time. The first production B-2707 will be used to show compliance with guaranteed noise levels for both ground and flight operations. These noise levels will be determined through a series of takeoff, flyby, landing approach, and static ground operations of the B-2707. Measurements will be made around the engine, under the flight path, and at specific distances to the side of the flight path to ensure that no significant data points are missed. Extensive use will be made of computerized data reduction and analysis techniques. FAA recommended procedures will be used for instrumentation calibration, data acquisition, and data analysis when such procedures are appropriate.

All test results obtained during the course of the Activities Program will be documented as each series of tests is completed. All documentation will be made available to the FAA, the airlines, and the airport operators.

REFERENCES

The following references are available at The Boeing Company, SST Division:

1. FAA letter to Mr. J. J. Werts from General J. C. Maxwell, "Interpretation of Exposure (PNdB Seconds) in the Request for Proposals Dated June 30, 1966," July 20, 1966

2. R. H. Sawhill Investigation of Inlet Airflow Choking As a Means of Suppressing Compressor Noise - 5" Inlet Model, D6A10155-1, The Boeing Company, June 1966

3. SAE Aerospace Information Report 876, Jet Noise Prediction, July 1965

4. C. F. Wintermeyer, Jet Engine Compressor and Fan Noise Prediction, D6A10334-1, The Boeing Company, August 1966

5. SAE Aerospace Recommended Practice Report 866, Standard Values of Atmospheric Absorption as a Function of Temperature and Humidity for Use in Evaluating Aircraft Flyover Noise, August 1964

6. SAE Aerospace Information Report 923, Extra Ground Attenuation of Sound, March 1966

7. J. V. O'Keefe, SST Engine Noise Suppression Study-Model Scale Test, Boeing Test Report T6A10341-1, August 1966

8. M. B. McKaig, Acoustic Test of High-Suppression Multitube Nozzle FS-1001 and Lined Shroud on J-75 Engine, Boeing Test Report T6-3599, August 6, 1966

9. M. B. McKaig, J-75 Inlet Noise Suppression Test, Boeing Test Report T6-3173, October 1964

10. M. B. McKaig, Fan-Discharge Noise Suppression Test on JT8D Engine, Boeing Test Report T6-3166, October 1964

11. A. J. Bohn, Internal Suppression of Compressor Noise of the JT3D-3B Engine With 3/4 Length Fan Ducts, Boeing Test Report T6-3498, March 1966

ILLUSTRATIONS

ILLUSTRATIONS (Cont.)

TABLES

ADDENDUM

SUMMARY REPORT - 8 AUGUST 1966 ENGINE PERFORMANCE DATA

The foregoing document is based upon engine performance data received prior to 15 July 1966.

Because there was insufficient time available to completely revise the B-2707 performance after receiving the 8 August 1966 firm technical engine data, the following summary is provided to show the major effect of the firm data on the airplane performance shown in the Phase III proposal documents. Only the most important figures have been provided herein.

If additional or supplemental data is needed, a request to The Boeing Company, SST Division, will receive immediate attention.

ADDENDUM

AIRPORT AND COMMUNITY NOISE

CONTENTS

SECTION 1.0
INTRODUCTION AND SUMMARY

The Boeing SST Proposal is prepared on the basis of engine manufacturer technical data received prior to July 15, 1966. On August 8, 1966, firm technical data was received from General Electric and Pratt & Whitney Aircraft which differed in some respects from the data received prior to July 15, 1966. The purpose of this addendum is to describe the significant differences and to summarize effects on performance of the Boeing Model 2707 airplane.

All information in the proposal is based on the July 15, 1966 engine data with the exception of the Phase III Proposal Summary, V1-B2707-1, Propulsion Report - Part C, Engine Evaluation, V2-B2707-14, and this addendum. These documents are based on engine data received from the engine manufacturers as of August 8, 1966.

1.1 ENGINE DIFFERENCES

The General Electric GE4/J5P engine data received on August 8, 1966, provided lower airport and community noise levels for all engine operating conditions. These lower noise levels were the result of redesign of the exhaust nozzle and noise suppression data obtained from J-93 engine testing. Acoustic data provided by General Electric also indicated reduced turbine noise from that being predicted by Boeing for the GE4/J5P engine. These changes provide significantly improved takeoff and approach noise for the B-2707 (GE). An improvement in transonic thrust was also provided. Updated installed engine weight, including optional equipment has resulted in a 112-lb weight increase for the GE4/J5P engine installation. Engine changes have not affected the installed pod configuration.

In the case of Pratt & Whitney Aircraft JTF17A-21B engine, a 2-percent reduction in specific fuel consumption (SFC) at essentially all operating conditions was the principal change. This improvement reduces B-2707 (P&WA) fuel consumed over the design mission and lowers the reserve fuel requirements. Updated installed engine weight including optional equipment has resulted in a 190-lb weight increase for the JTF17A-21B engine installation. Engine changes have not affected the installed pod configuration.

1.2 AIRPLANE PERFORMANCE

The major effects of these engine changes on airplane performance are summarized in Table 1-A for the international B-2707 with a maximum design taxi weight of 675,000 lb and in Table 1-B for the domestic airplane with a maximum design taxi weight of 575,000 lb. The improved hot day range capability and noise characteristics of the B-2707 (GE) are apparent, as is the improved range capability of the B-2707 (P&WA).

Table 1-A. Performance Changes International Mission

Maximum Taxi Gross Weight = 675,000 lb		B-2707 (GE)		B-2707 (P&WA)	
		July 15, 1966 Basis	Aug. 8, 1966 Basis	July 15, 1966 Basis	Aug. 8, 1966 Basis
Operational Empty Weight lb		287,500	287,500	285,000	285,760
Range with 50,000 lb Payload					
ΔP_{max} = 2.5 psf					
Standard Day, n mi		3,819	3,819	3,738	3,808
Standard Day + 10°C, n mi		3,471	3,580	3,470	3,547
M_{MO} Climb					
Standard Day, nmi		3,950	3,928	3,882	3,970
M = 0.85 Cruise					
Standard Day, nmi		3,286	3,286	3,870	3,950
Takeoff Noise, PNdb Maximum Augmented Thrust					
Standard Day	Airport Noise	121	117	117	117
	Community Noise cg at 0.595 C_R cg at 0.615 C_R	 100 99	 96 95	 105 104	 105 104
Standard Day + 15°C	Airport Noise	121	117	117	117
	Community Noise cg at 0.595 C_R	 105	 102	 110	 110
Landing Approach Noise, PNdB Standard Day					
Landing Weight, lb		430,000	430,000	420,000	420,000
20°/40° Flaps	cg at 0.595 C_R	112	105	115	115
	cg at 0.615 C_R	111	103	114	114
30°/50° Flaps	cg at 0.615 C_R	113	107	116	116
Decelerating Approach		108	98	111	111

Table 1-B. Performance Changes, Domestic Mission

		Domestic B-2707 (GE)		Domestic B-2707 (P&WA)	
Maximum Taxi Gross Weight = 575,000 lb		July 15, 1966 Basis	Aug. 8, 1966 Basis	July 15, 1966 Basis	Aug. 8, 1966 Basis
Operational Empty Weight lb		275,500	275,500	273,000	273,760
Range with 50,000 lb Payload					
ΔP_{max} = 2.0 psf Climb; 1.5 psf Cruise					
Standard Day, nmi		2,450	2,465	2,442	2,493
Standard Day + 10°C, nmi		2,295	2,368	2,268	2,307
M = 0.85 Cruise					
Standard Day, nmi		2,571	2,571	3,042	3,100
Takeoff Noise, PNdb		Maximum Dry Thrust		80% Maximum Aug. Thrust	
Standard Day	Airport Noise	117	115	114	114
	Community Noise cg at 0.595 C_R	99	93	103	103
	cg at 0.615 C_R	98	92	102	102
Standard Day + 15°C	Airport Noise	116	114	114	114
	Community Noise cg at 0.595 C_R	107	99	108	108
Landing Approach Noise, PNdB Standard Day					
Landing Weight, lb		410,000	410,000	400,000	400,000
$20^{\circ}/40^{\circ}$ Flaps	cg at 0.595 C_R	112	104	115	115
	cg at 0.615 C_R	110	102	114	114
$30^{\circ}/50^{\circ}$ Flaps	cg at 0.615 C_R	112	106	116	116
Decelerating Approach		108	98	111	111

SECTION 2.0
ENGINE CHANGES

2.1 PERFORMANCE

2.1.1 General Electric GE4/J5P Engine

A 6-percent improvement in transonic thrust was provided as well as increased transonic hot day thrust by means of higher engine rpm and increased airflow for an incremental 50-lb weight increase. Figure 2-1 shows the change in hot day transonic thrust for a 2.5 PSF sonic boom overpressure climb path. Reduced transonic inlet drag due to lower bypass airflow is also shown.

2.1.2 Pratt & Whitney Aircraft JTF17A-21B Engine

The two percent SFC reduction for the JTF17A-21B engine at all power settings except idle power is listed in Table 2-A for important B-2707 operating points. This improvement is provided as a result of increased component efficiencies demonstrated in primary burner, duct burner, and nozzle component development programs.

2.2 INSTALLATION

Pod configuration and external contours for both engine installations are unchanged. The final installed pod weights for both engines including added weight for optional equipment are listed in Table 2-B.

2.3 NOISE

The noise characteristics of the JTF17A-21B remain unchanged from those data presented in the body of the Boeing SST proposal. The remainder of the discussion concerns the GE4/J5P engine.

2.3.1 Engine Noise Characteristics GE4/J5P

The engine noise characteristics of the GE4/J5P engine have been predicted from the engine data and jet noise suppression as supplied by General Electric. Additional engine noise suppression achieved through inlet choking by use of the sonic throat principle as described in the Airport and Community Noise Program report, V4-B2707-4, has also been included. The jet noise suppression values used in the calculation of noise levels for the GE4/J5P engine are shown in Fig. 2-2. These values have been determined by General Electric through acoustic tests that have been conducted on a J-93 engine.

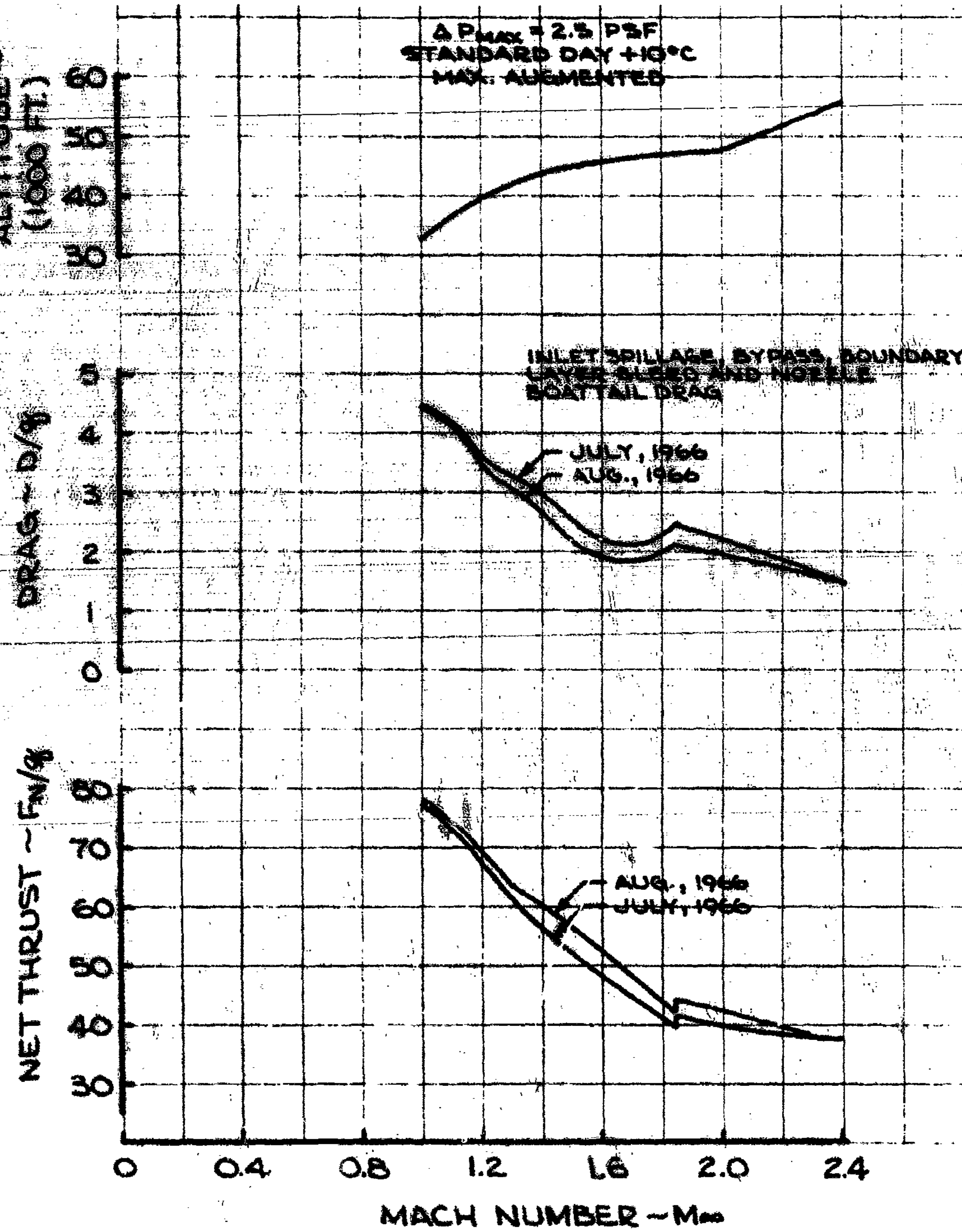


Figure 2-1. GE4/J5P Climb Performance, Standard Day + 10°C

Table 2-A. JTF17A-21B Performance Summary

Power Setting	Pressure Altitude ft	Temperature	Mach No	Net Thrust lb	July-1966 SFC lb/hr/lb	August-1966 SFC lb/hr/lb
Max Augmented	0	Std	0	56,740	1.86	1.83
Max Non-Augmented	0	Std	0	35,490	0.77	0.76
Max Augmented	45,000	Std	1.2	19,630	1.94	1.90
Max Augmented	45,000	Std + 10°C	1.2	18,140	2.00	1.96
Partial Augmented	65,000	Std	2.7	15,000	1.57	1.54
Partial Augmented	65,000	Std + 10°C	2.61	15,000	1.66	1.63
Partial Non-Augmented	36,150	Std	0.85	5,000	1.07	1.06
Partial Non-Augmented	15,000	Std	0.5	5,000	1.10	1.08

2.3.1 (Continued)

The unsuppressed noise levels for the GE4/J5P engine for ground and flight operations are shown in Figs. 2-3 and 2-4. Also shown in these figures are the predicted noise levels with all suppression included. The effect of the open-nozzle concept wherein the nozzle throat area is maintained on a maximum area schedule is included in the suppressed noise level predictions. The predicted noise spectra for a series of engine operating conditions have also been predicted and are presented in Table 2-C.

Noise levels beneath and to the side of the airplane flight path have been determined from the revised noise data. These levels have been integrated into contours of Perceived Noise Level for takeoff. These contours are shown for the B-2707 (GE) international airplane in Fig. 4-12 and the B-2707 (GE) domestic airplane in Fig. 4-14.

The landing noise characteristics of the B-2707 (GE) have changed significantly due to the noise data presented on August 8, 1966. These data indicated that turbine noise would not contribute significantly to the total noise from the airplane even at landing approach power settings. Boeing had been predicting very significant noise increases due to turbine noise contribution. The predictions were based on the J-75 engine acoustic test results. Since the GE data were obtained on an engine more closely resembling the SST turbojet offering, these data should be more representative of the noise characteristics of the SST engine. Therefore the B-2707 landing noise levels have been revised to conform to the August 8, 1966 data inputs. The results of these revisions are shown in Figs. 4-17 and 4-18.

Table 2-B. Installed Pod Weight

	B-2707 (GE)	B-2707 (P&WA)
Engine weight	11,125	9,910
Optional equipment	112	730
Total	11,237	10,640
Inlet	2,070	2,485
Cowl panels		
Forward	325	225
Aft	150	---
Structure	495	480
Miscellaneous	35	35
Total	14,312	13,865

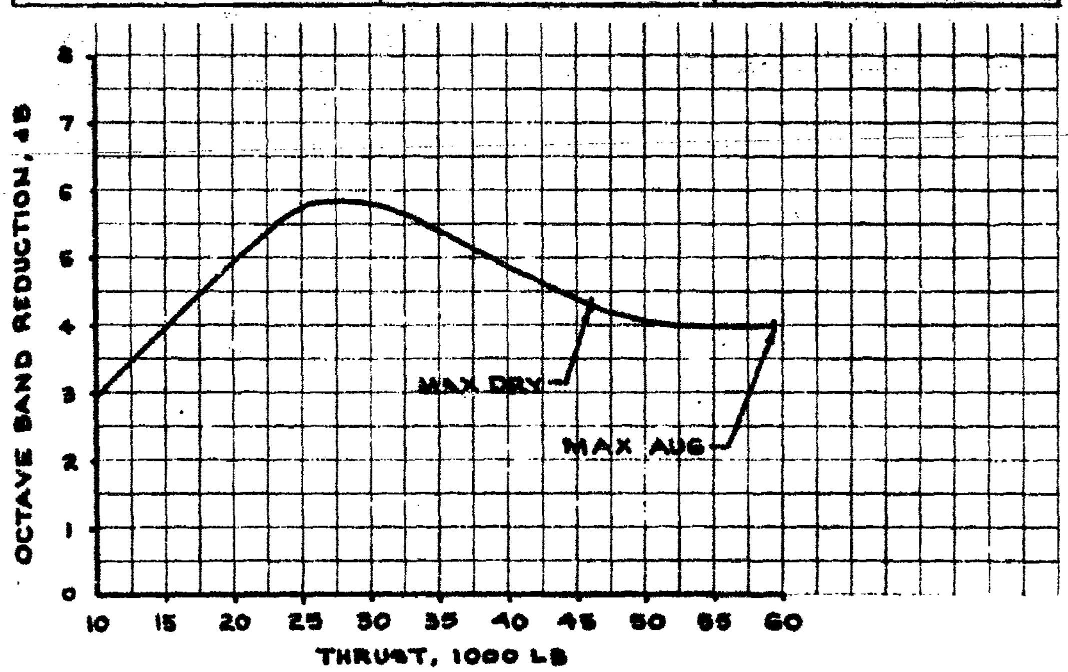


Figure 2-2. Predicted GE4/J5P Jet Noise Suppression

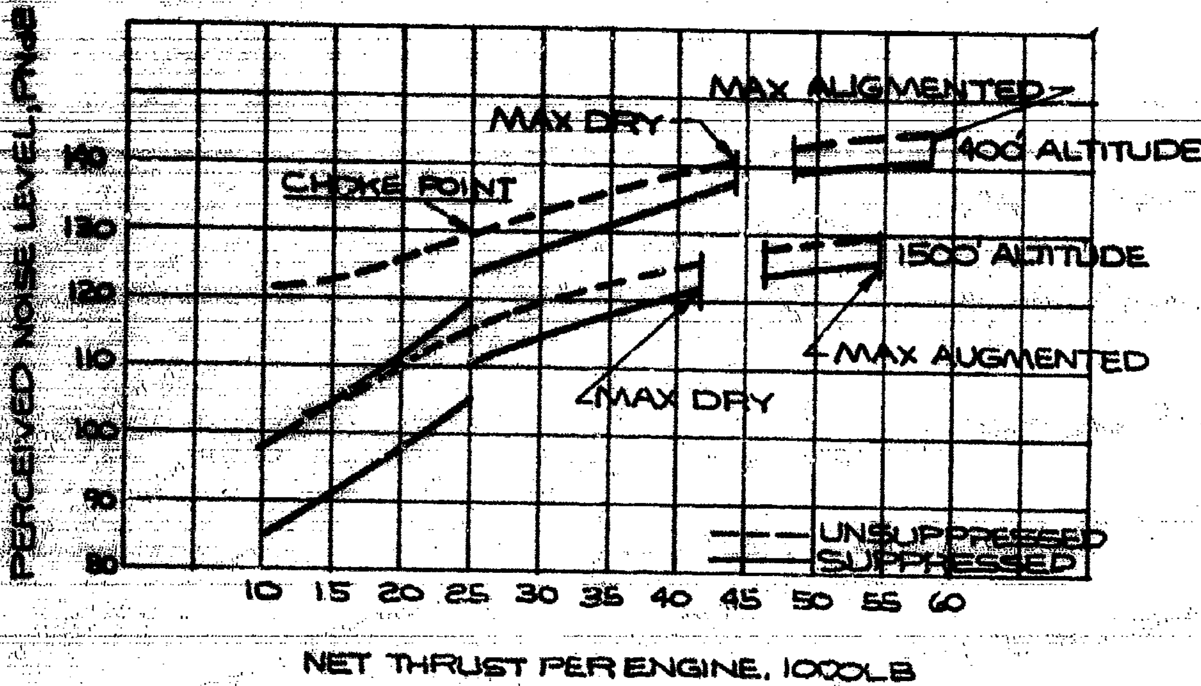


Figure 2–3. Inflight Noise Characteristics of GE4/J5P Engines

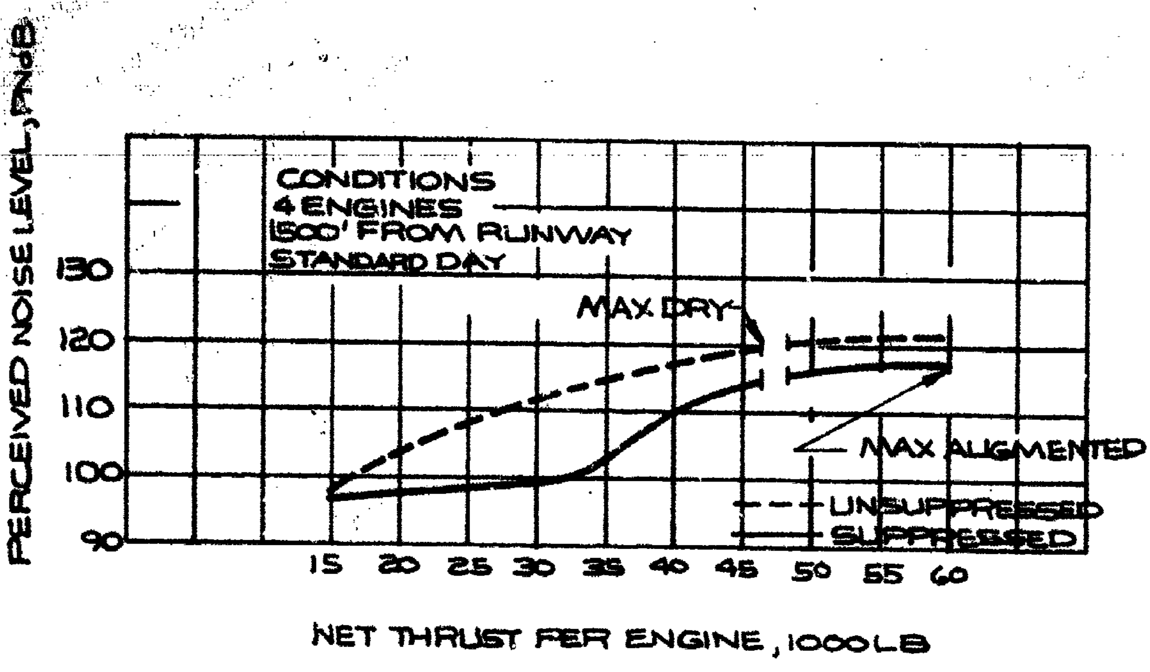


Figure 2–4. Noise Characteristics of GE4/J5P Engines For Static Ground Operations

Table 2-C. Noise Spectra For GE4/J5P Engine

Operating Conditions (4 Engines)	Overall SPL	Octave Band Sound Pressure Level - (db) 1	2	3	4	5	6		7		8		Per-ceived Noise
	(dB)	Jet	Jet	Jet	Jet	Jet	Jet	Comp	Jet	Comp	Jet	Comp	(PNdB)
Ground Static - 1,500 Ft													
Max Aug - Unsuppressed	118.5	113	115	113	109	102	92	75	78	44	61	62	121.0
- Suppressed	114.5	109	111	109	105	98	88	75	74	74	57	62	117.0
Max Dry - Unsuppressed	117.0	111	113	111	107	100	90	75	76	74	60	62	119.0
- Suppressed	113.0	107	109	106	103	98	86	75	72	74	56	62	114.5
Taxi (5,000 lb/Fn) - 200 Ft													
- Unsuppressed	106.0	85	85	82	80	75	70	101	65	102	60	100	119.0
- Suppressed	97.0	85	85	82	80	75	70	91	65	92	60	90	111.0
Flight (0.3 M) - 1,500 Ft Alt													
Max Aug - Unsuppressed	125.5	113	118	121	118	114	108	87	95	86	77	74	130
- Suppressed	121.0	109	114	117	114	110	104	37	91	86	73	74	126
Max Dry - Unsuppressed	122.0	110	116	117	115	111	104	87	90	86	73	74	126.5
- Suppressed	118.0	106	112	112	111	107	100	87	86	86	69	74	112.0
18,500 lb/Fn - Unsuppressed	99.0	93	94	93	89	83	75	86	61	85	44	75	107
- Suppressed	95.0	89	90	89	84	78	70	61	61	60	43	50	97
15,700 lb/Fn - Unsuppressed	96.0	90	91	90	85	80	72	82	58	81	41	68	105
- Suppressed	92.5	86	87	86	81	76	68	57	54	56	37	43	94
Landing (0.23 M) - 326 Ft Alt													
- Unsuppressed	111.5	101	100	98	94	89	84	101	79	107	74	103	124
- Suppressed	101.5	97	96	94	90	85	80	77	75	82	70	78	105

SECTION 3.0
AIRPLANE WEIGHT EFFECTS

The Airframe Design Report - Part A, Weight and Balance, gives an Operating Empty Weight breakdown of the GE and P&WA powered airplanes. Table 3-A lists these comparative weights as they are modified by the August 8, 1966 engine data and other related airplane changes.

The 760-lb weight change in the P&WA powered airplane increases the Manufacturer's Empty Weight, Operating Empty Weight and Zero Fuel Weight of the following P&WA powered airplanes:

a. 635,000-lb gross weight design point airplane

b. 675,000-lb gross weight production international airplane

c. 635,000-lb gross weight prototype airplane

d. 575,000-lb gross weight production domestic airplane

TABLE 3-A
OPERATING EMPTY WEIGHT

GROUP	GE	P&WA
Engines	44,950	42,560
Nacelle	12,300	12,900
Horizontal Tail	20,400	20,460
Engine Accessories - ADS	1,100	1,160
Anti-Icing and Anti-Fogging	280	330
Starting System	400	430
Fuel System	7,400	7,510
Hydraulic System	3,600 [1]	3,420
Body Structure	47,300 [1]	47,220
Other	149,770	149,770
Operational Empty Weight (Max. design taxi weight 675,000 lb)	287,500	285,760
Original Operating Empty Weight	287,500	285,000
Weight Change	0	+760 lb

[1] Includes effect of ram air turbine - B-2707 (GE) only

SECTION 4.0
AIRPLANE PERFORMANCE

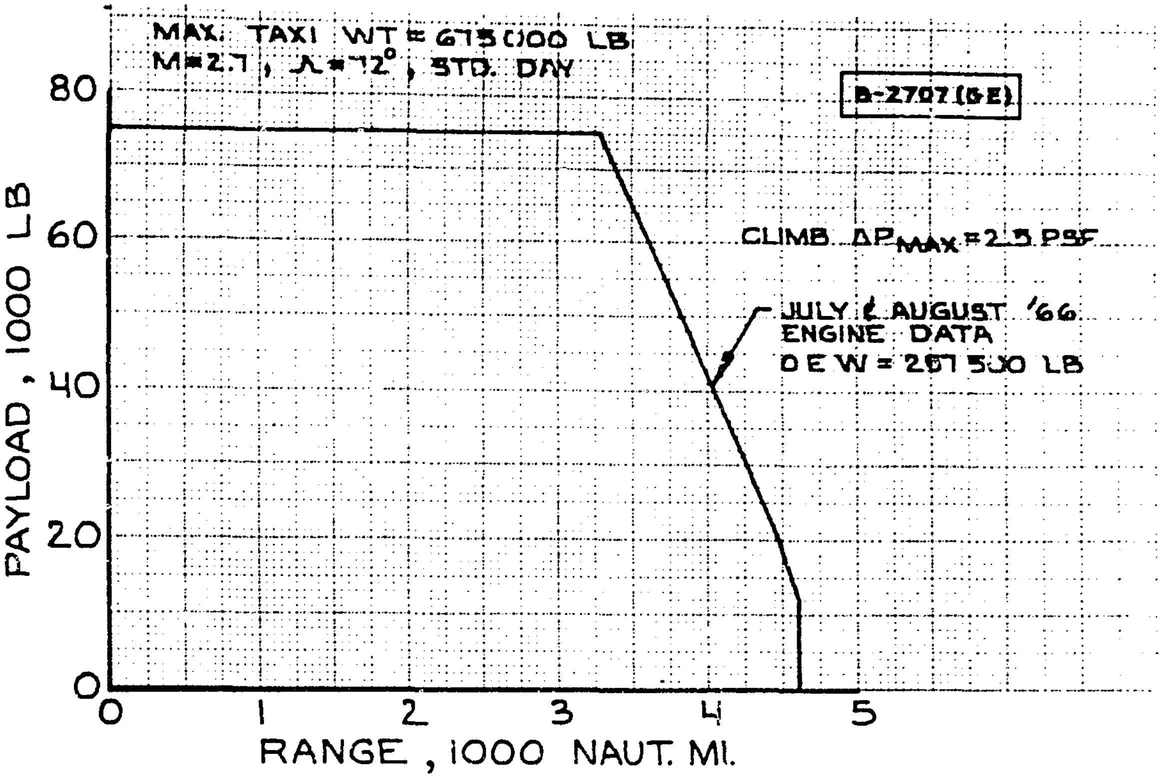
The effect of the changes in engine data on the standard day payload-range capability are illustrated in Fig. 4-1 for the International B-2707 and Fig. 4-2 for the domestic airplane. As noted, there is no significant effect on the standard day range of the B-2707 (GE). The improved specific fuel consumption of the Pratt & Whitney Aircraft engine results in slightly less than 2 percent increase in range. The effect of temperature changes from standard day on range are shown in Fig. 4-3 for the B-2707 (GE) and Fig. 4-4 for the B2707 (P&WA). There is no change for the B-2707 (P&WA) curve since the effect of temperature on the engine data did not change.

Figures 4-5 and 4-6 show the off-loaded supersonic range capability and corresponding transonic thrust margins for the airplanes. The range performance with a mixed subsonic and supersonic mission is shown in Fig. 4-7. Figures 4-8 and 4-9 show fuel, time, and distance breakdowns for a nominal, standard day, intercontinental mission at a maximum sonic-boom overpressure of 2.5 psf for both airplanes.

Summaries of takeoff performance, using maximum augmented thrust, are shown in Figs. 4-10 and 4-11. The significant change in takeoff performance is in the airport and community noise of the B-2707 (GE). The changes in noise characteristics are shown in more detail by the noise contours around the airport in Figs. 4-12 through 4-15.

The noise data shown on the preceding curves are based on the engines as proposed by the engine contractors with the use of a sonic throat in the inlet at reduced powers. With the Boeing noise suppressor, the August 8, 1966 General Electric engine data have resulted in an additional 1 PNdb reduction in the airplane's noise characteristics at maximum augmented thrust. Noise contours with the Boeing jet suppressor are compared in Fig. 4-16 for the B-2707 (GE).

The only change in landing performance for the airplanes caused by the changed engine data is in the approach noise for the B-2707 (GE) as shown in Figs. 4-17 and 4-18. Figure 4-19 shows the B-2707 (P&W) landing performance.



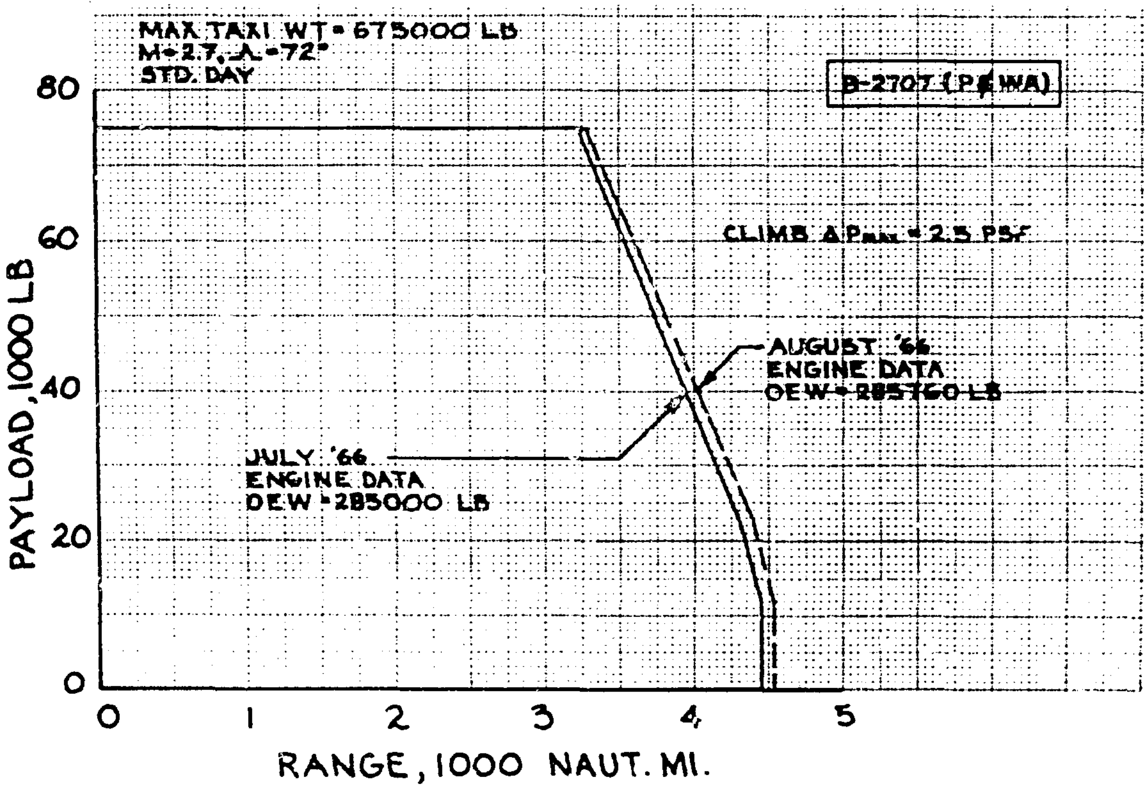


Figure 4-1. Payload-Range, International Model B-2707

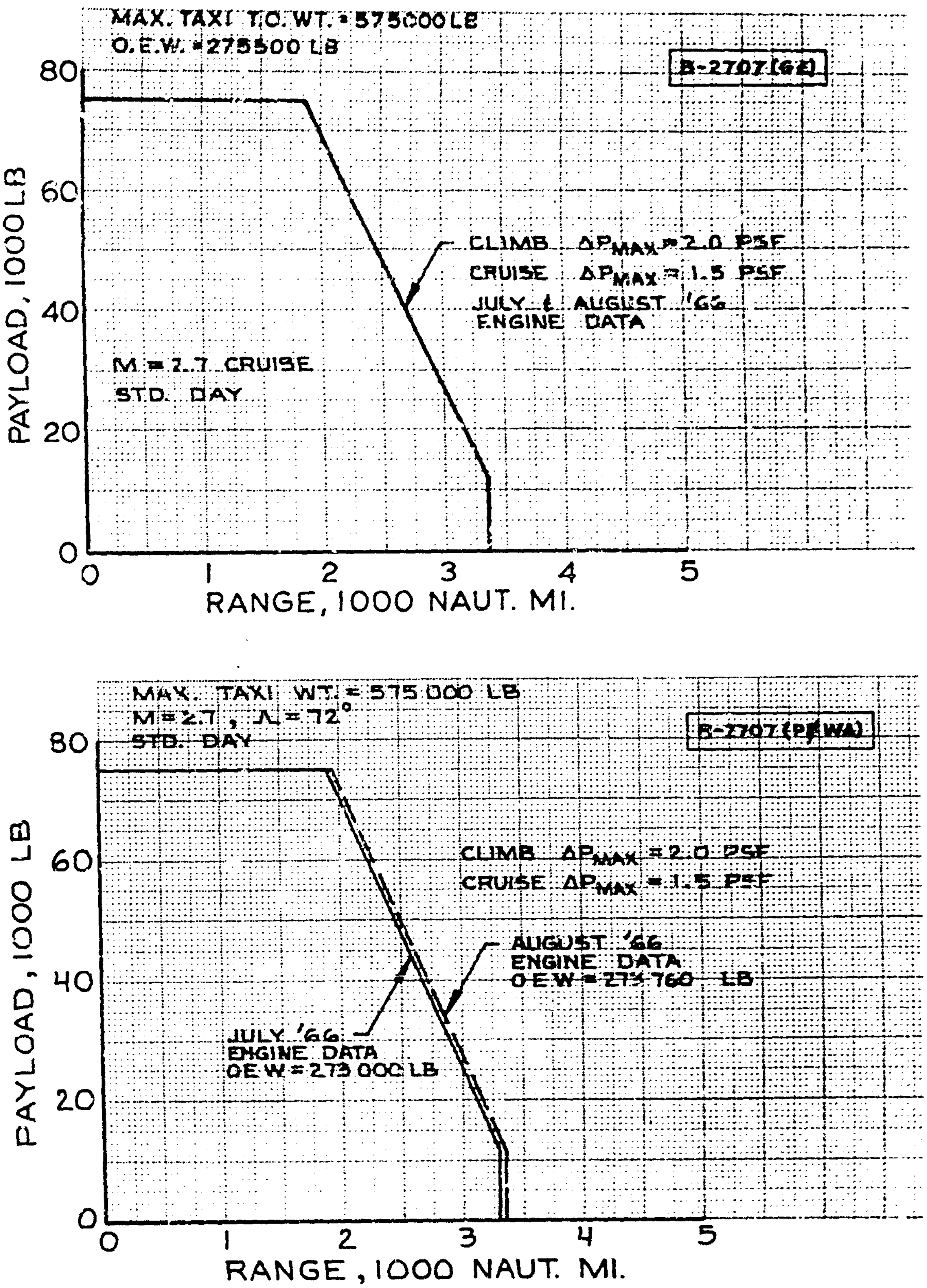


Figure 4-2. Payload-Range, Domestic Model B-2707

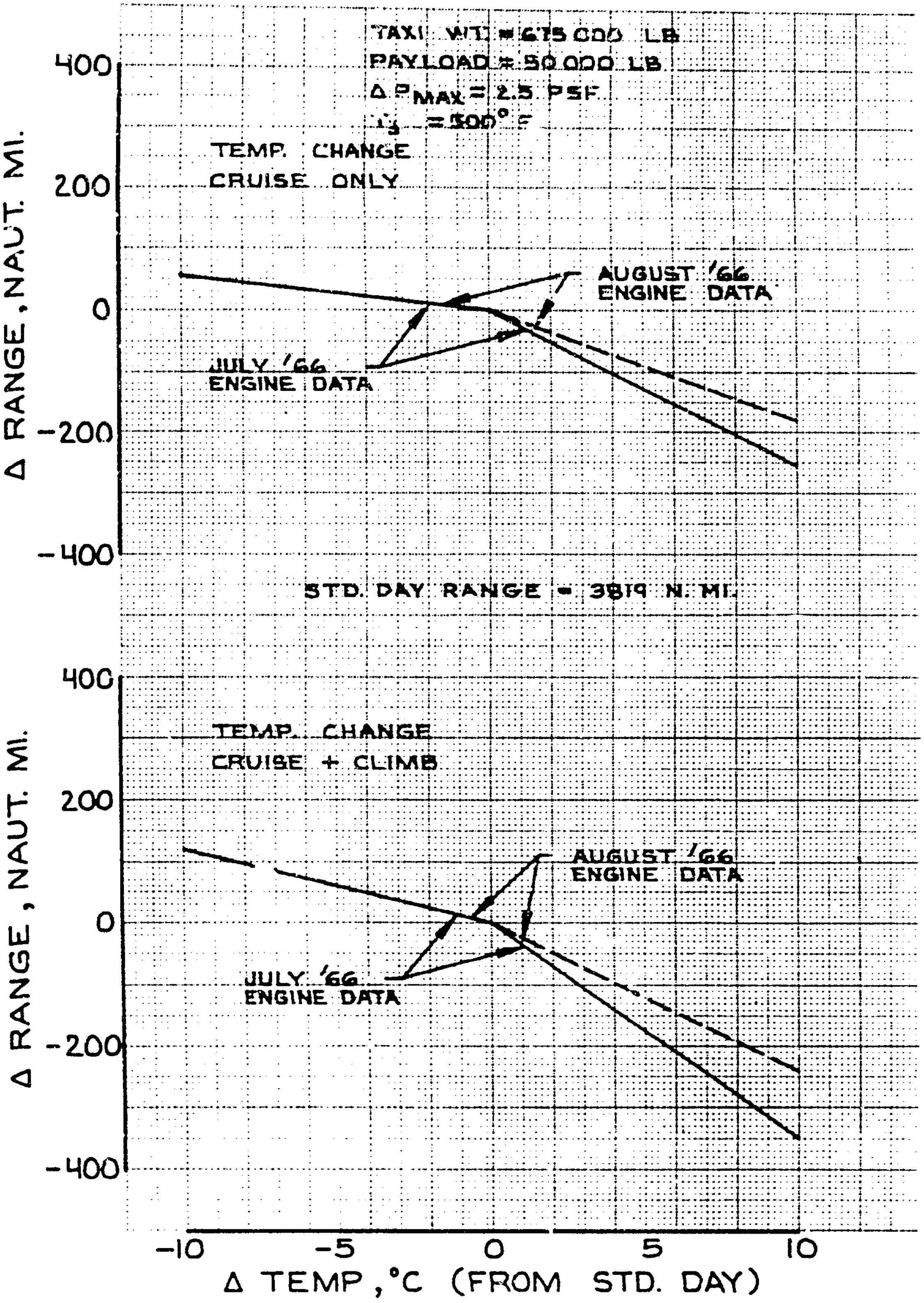


Figure 4-3. Effect of Temperature Change on Range Model B-2707 (GE)

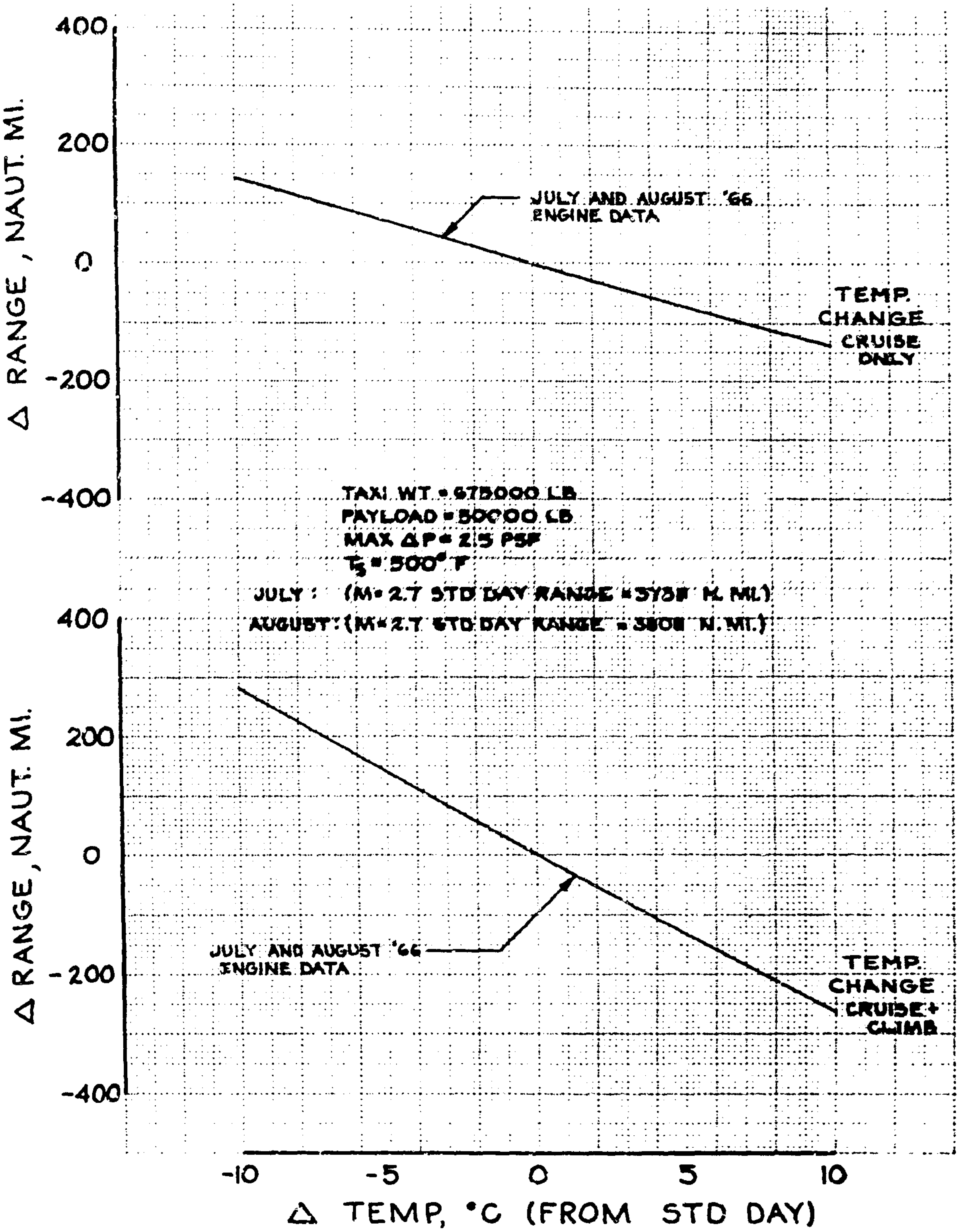


Figure 4–4. Effect of Temperature Change on Range Model B–2707 (P&WA)

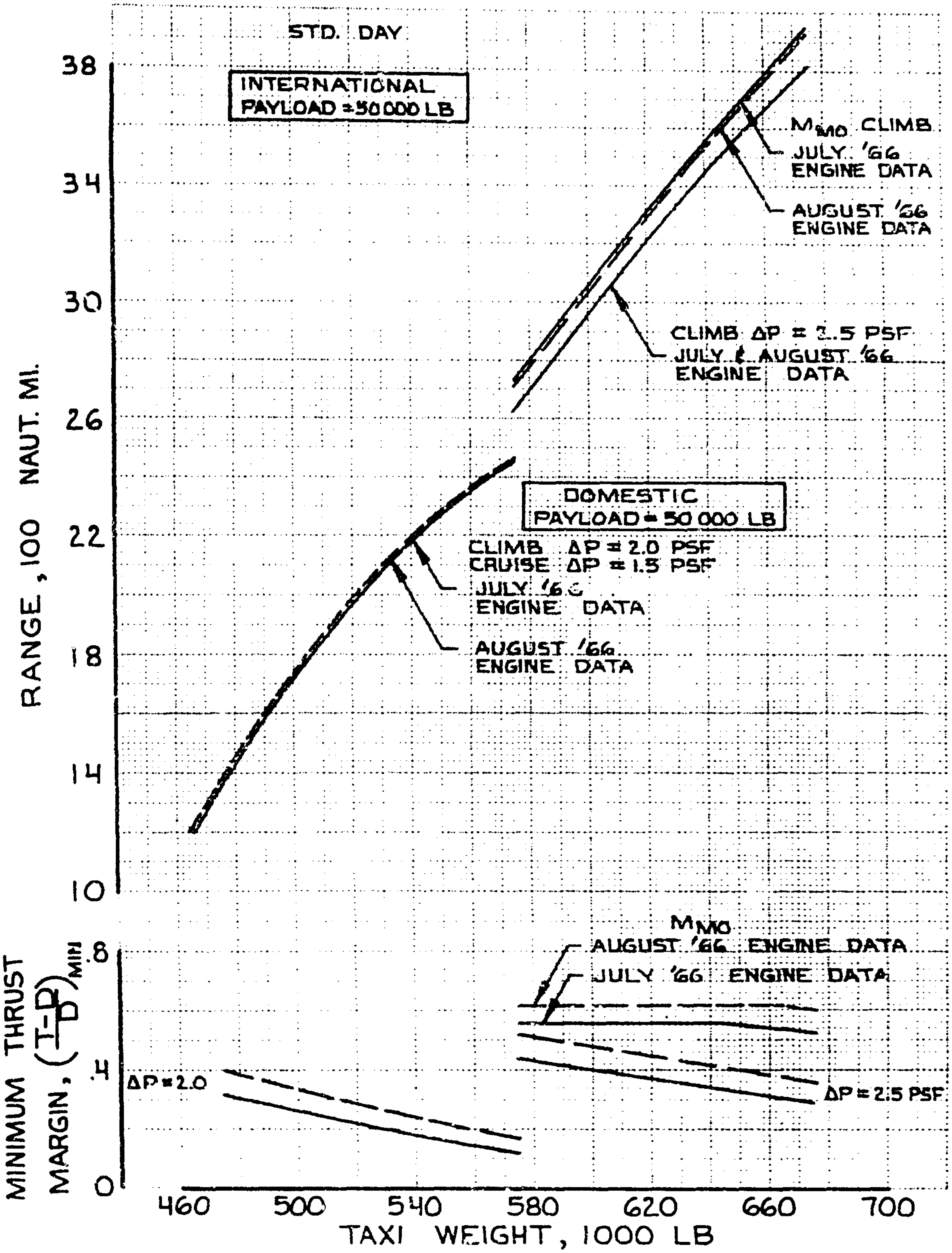


Figure 4-5. Off-Loaded Airplane Performance Model B-2707 (GE)

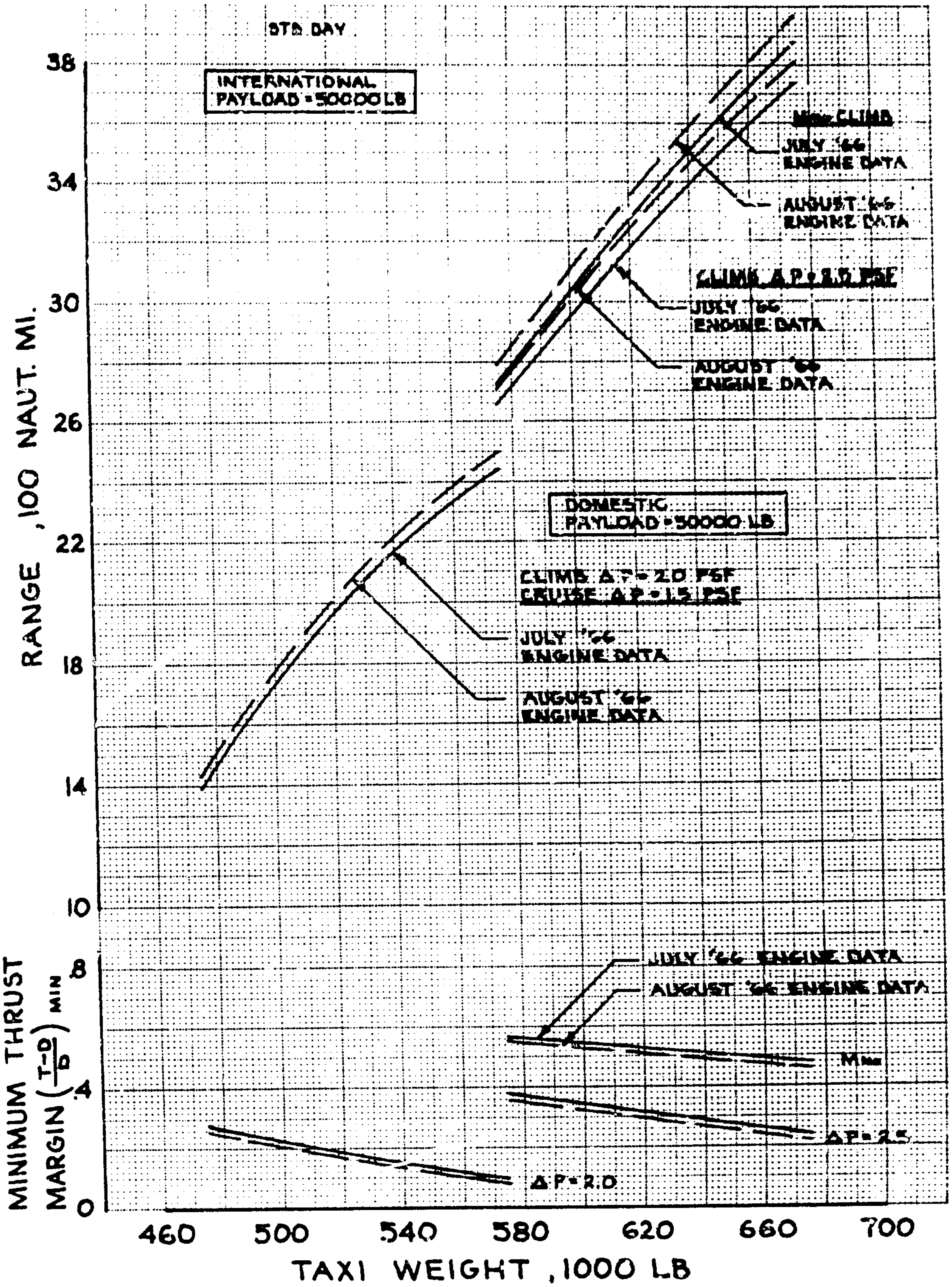
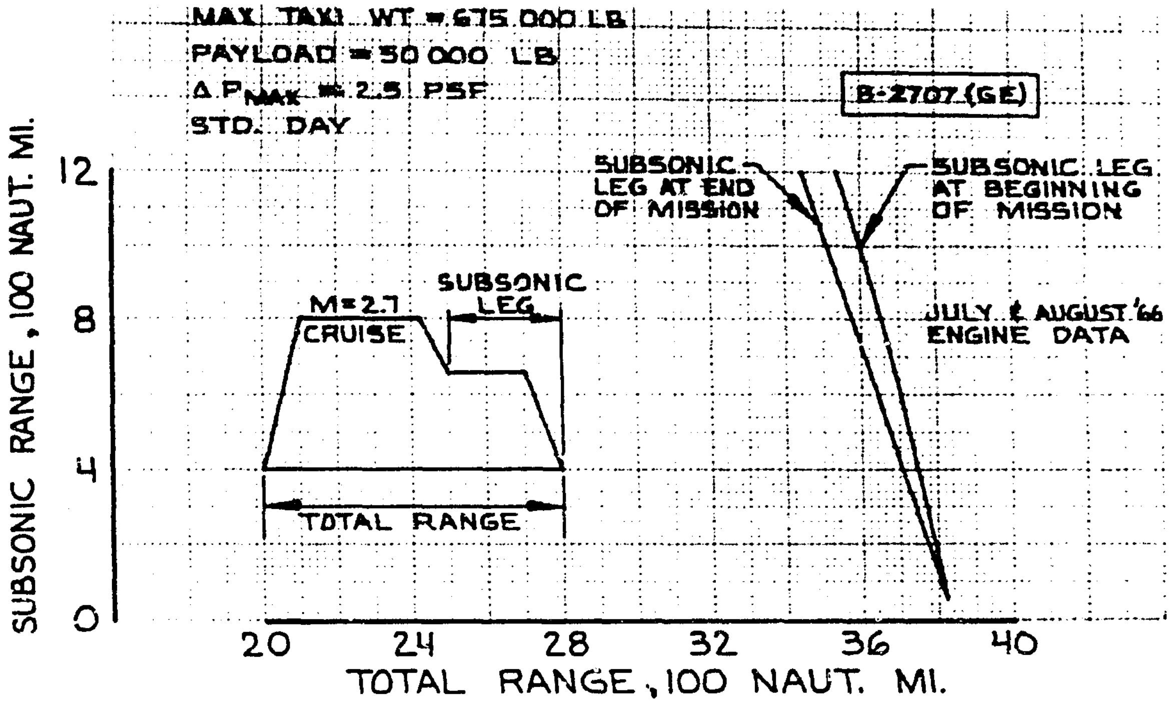


Figure 4–6. Off–Loaded Airplane Performance Model B–2707 (P&WA)



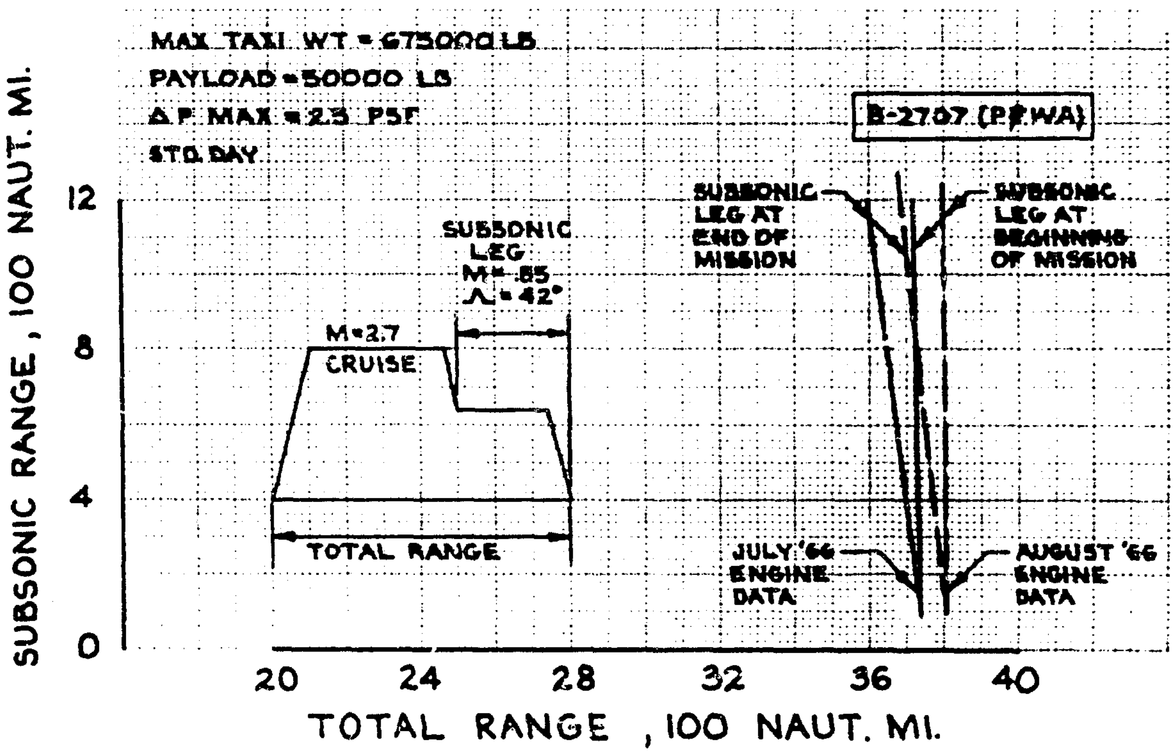
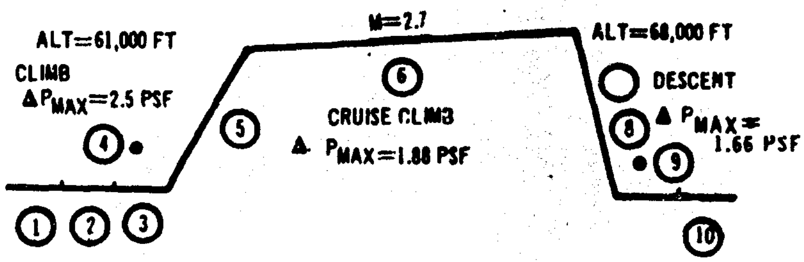


Figure 4-7. Operational Versatility Model B-2707

Max. Design
Taxi Weight = 675,000 lb
OEW = 287,500 lb
Payload = 50,000 lb
Wing Area = 9,000 ft^2
Engine = GE4/J5P
Airflow = 620 lb/sec

Std Day, Zero Wind
Phase III Rules
Block Time = 3.290 hr
Block Fuel = 292,181 lb



	Fuel Burned (lb)	Fuel Remaining (lb)	Weight At End of Operation (lb)	Time (hr)	Distance (nmi)
1. Taxi-out	4,060	333,440	670,940	0.167	—
2. Takeoff (Sea level to 35 ft)	4,150	329,290	666,790	0.010	—
3. Acceleration to climb speed	4,790	324,500	662,000	0.024	5.0
4. Departure air maneuver allowance (250 kts EAS & 5,000 ft)	4,000	320,500	658,000	0.0673	—
5. Acceleration and climb	81,400	238,800	576,600	0.411	337
6. Supersonic cruise climb	186,791	52,309	389,809	2.112	3271
7. & 8. Deceleration and descent (cruise altitude to 1,500 ft)	2,330	49,979	387,479	0.333	206
9. Destination air maneuver (Approach & Landing Allowance, 250 kts EAS at 5,000 ft) WT = WT at (8) = 5% block fuel	2,940	47,039	384,539	0.083	—
10. Taxi-in	(1,720)*			0.083	—
TOTAL MISSION	290,461			3.290	3819
Reserves					
A. 5 percent block fuel	14,609		369,930		
B. Missed approach (climb sea level to 1,500 ft)	2,510		367,420		
C. Climb from 1,500 ft subsonic cruise, descent to sea level at altn (300 st mi)	20,070		347,350		
D. 20 min hold at 15,000 ft over alternate	9,850		337,500		
TOTAL RESERVES	47,039				
TOTAL FUEL	337,500				

* Fuel burned not included in mission fuel; for D.O.C. only

Figure 4-8 B-2707 (GE) International Supersonic Cruise Mission

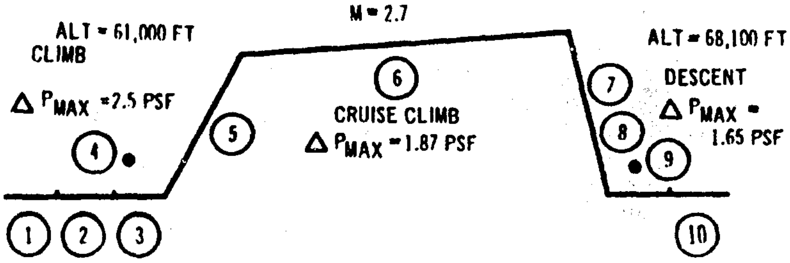
Max Design

Taxi Weight	675,000 lb
OEW	= 285,760 lb
Payload	50,000 lb
Wing Area	= 9,000 sq ft
Engine	= PWAJT F17A-21B
W_a	= 687 lb/sec

Std Day, Zero Wind

Phase III Rules

Block Time	= 3.400 hr
Block Fuel	297,890 lb



	Fuel Burned (lb)	Fuel Remaining (lb)	Weight At End of Operation (lb)	Time (hr)	Distance (nmi)
1. Taxi-out	2,880	336,360	672,120	0.167	—
2. Takeoff (Sea level to 35 ft)	4,385	331,975	667,735	0.010	—
3. Acceleration to climb speed	4,880	327,095	662,855	0.043	10
4. Departure air maneuver allowance (250 kts EAS & 5,000 ft)	3,160	323,935	659,695	0.067	
5. Acceleration and climb	95,400	228,535	564,295	0.570	422
6. Supersonic cruise climb	181,626	46,909	382,669	2.051	3,180
7. & 8. Deceleration and descent (cruise altitude to 1,500 ft)	2,070	44,839	380,599	0.326	196
9. Destination air maneuver (Approach & Landing Allowance, 250 kts EAS at 5,000 ft) WT = WT at (8) - 5% block fuel	2,234	42,605	378,365	0.083	—
10. Taxi-in	(1,255)*			0.083	—
TOTAL MISSION	296,635			3.400	3,808
Reserves					
A. 5 percent block fuel	14,895		363,470		
B. Missed approach (climb sea level to 1,500 ft)	2,200		361,270		
C. Climb from 1,500 ft subsonic cruise, descend to sea level at altn (300 st mi)	17,670		343,600		
D. 20 min hold at 15,000 ft over alternate	7,840		335,760		
TOTAL RESERVES	42,605				
TOTAL FUEL	339,240				

* Fuel burned not included in mission fuel; for D.O.C. only

Figure 4-9 B-2707 (P&WA) International Supersonic Cruise Mission

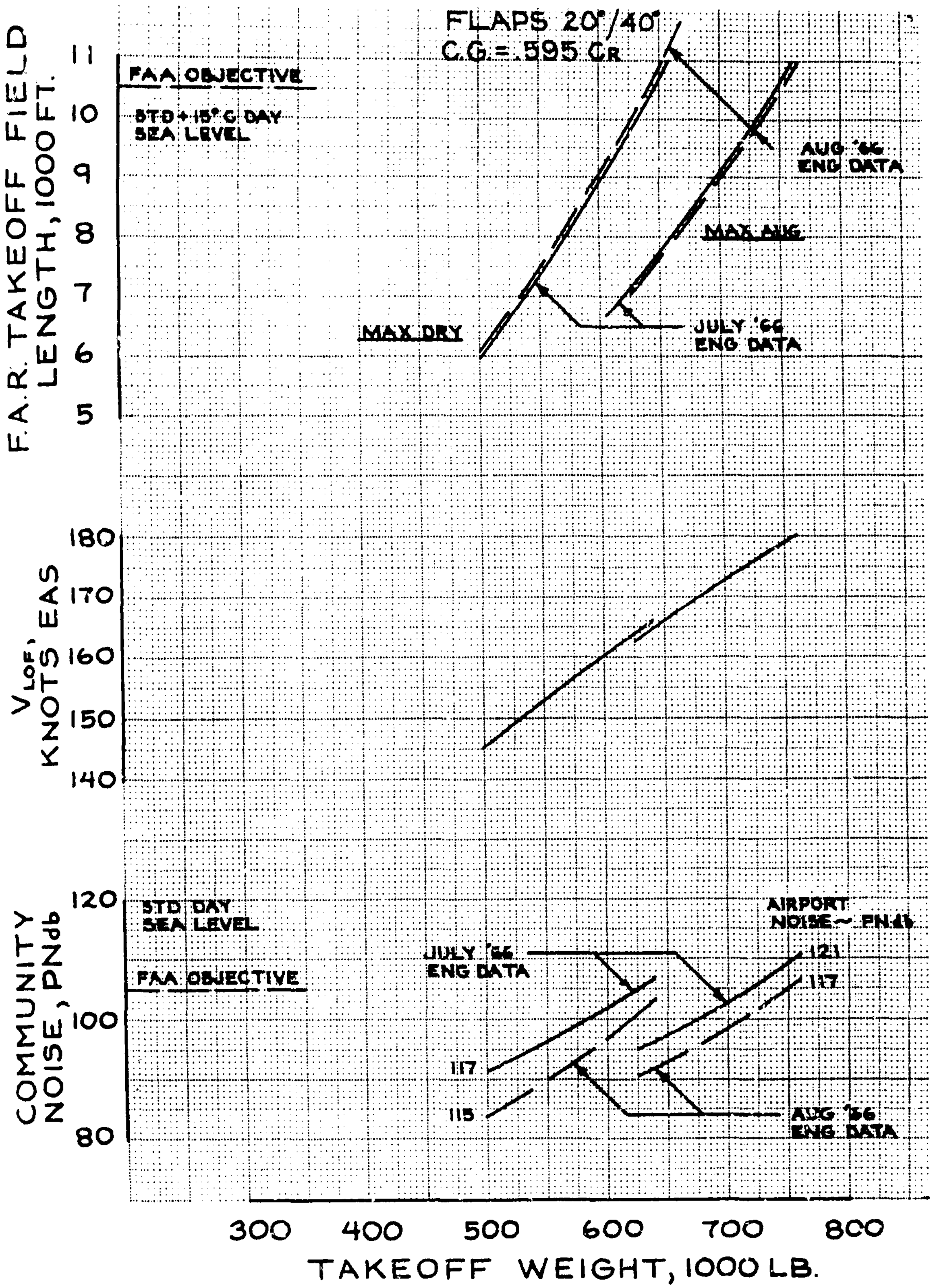


Figure 4–10. Takeoff Performance Model B–2707 (GE)

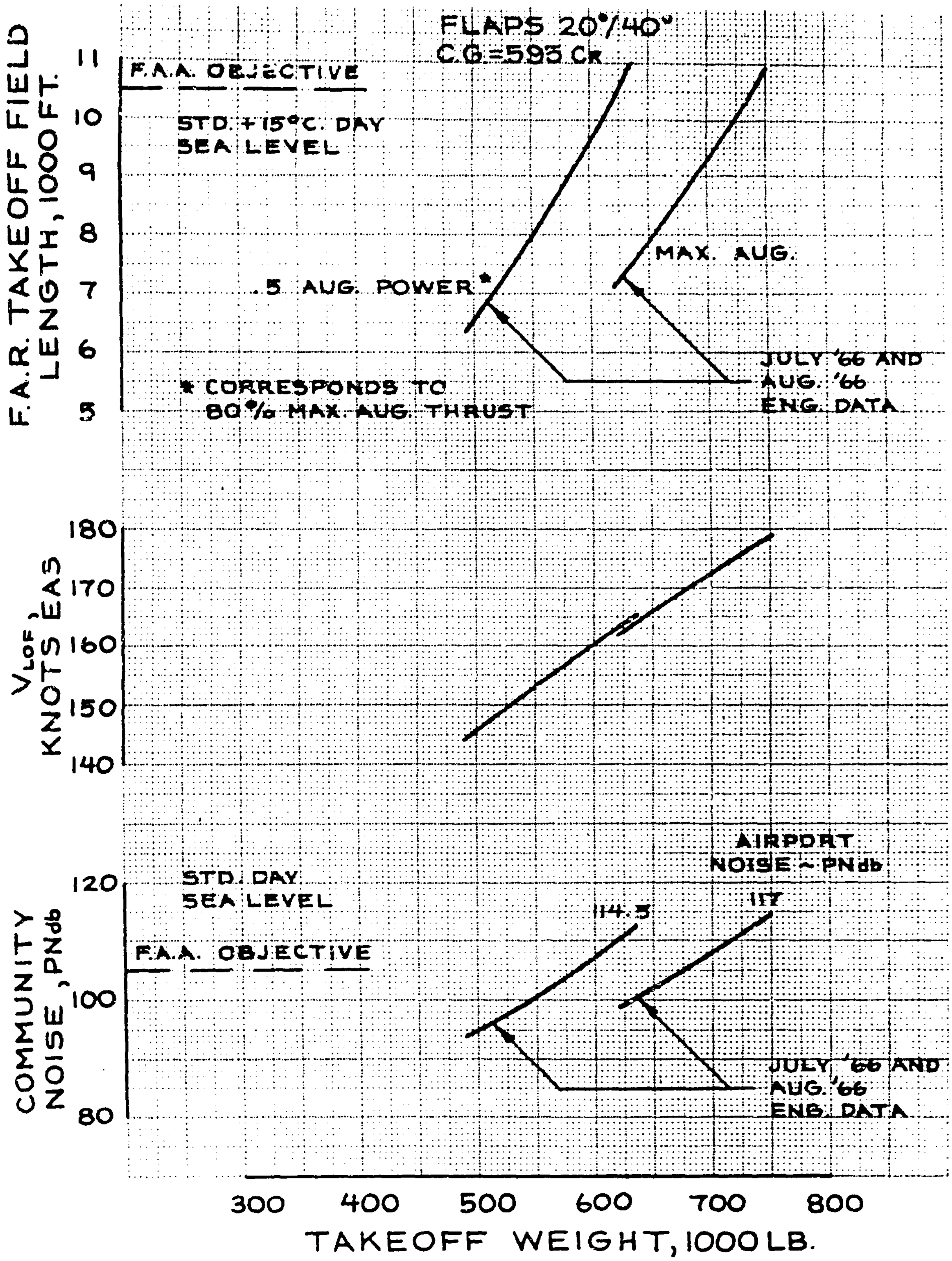


Figure 4-11. Takeoff Performance Model B-2707(P&WA)

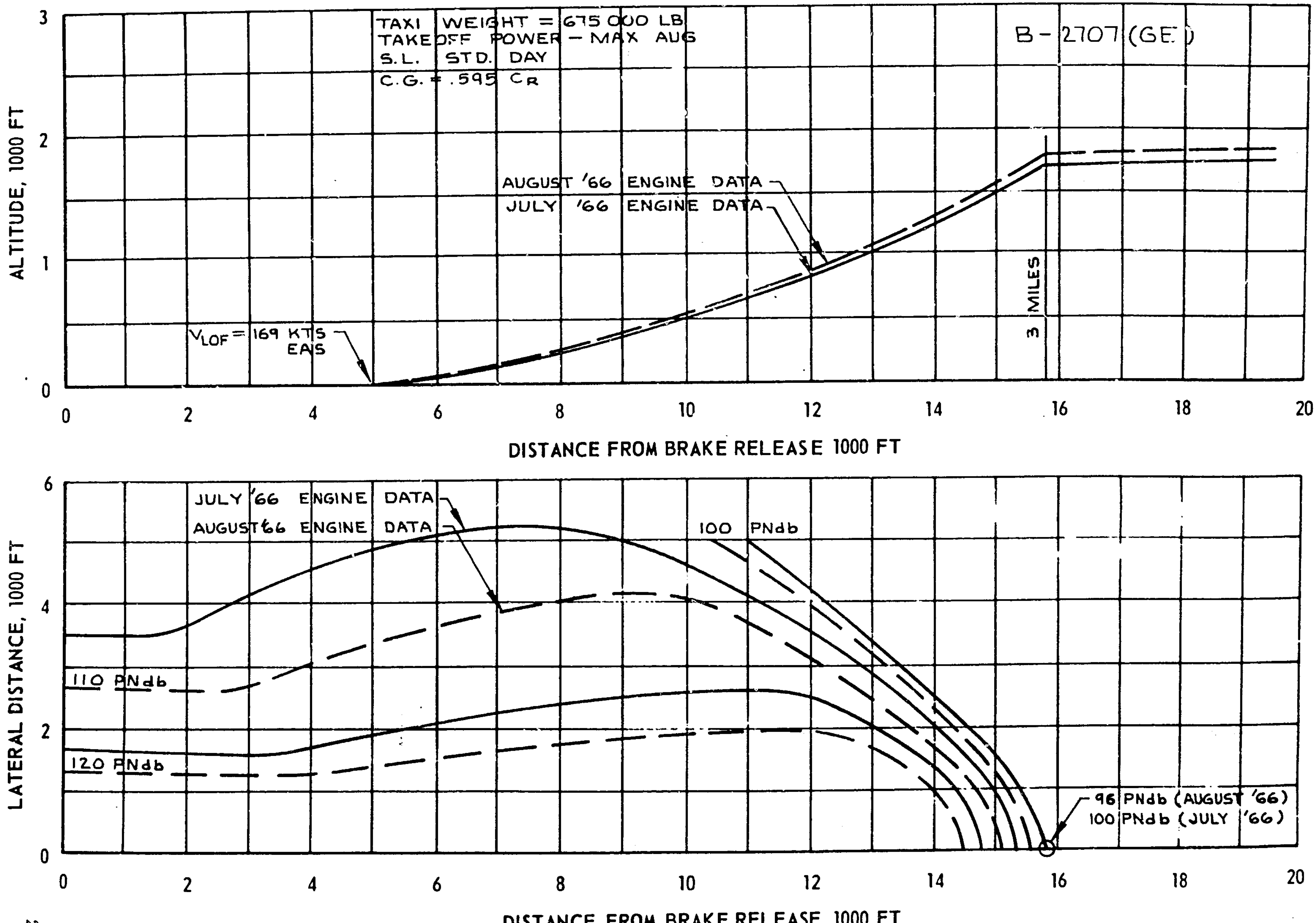


Figure 4–12. Noise Contours, International Mission, Standard Day Model B–2707 (GE)

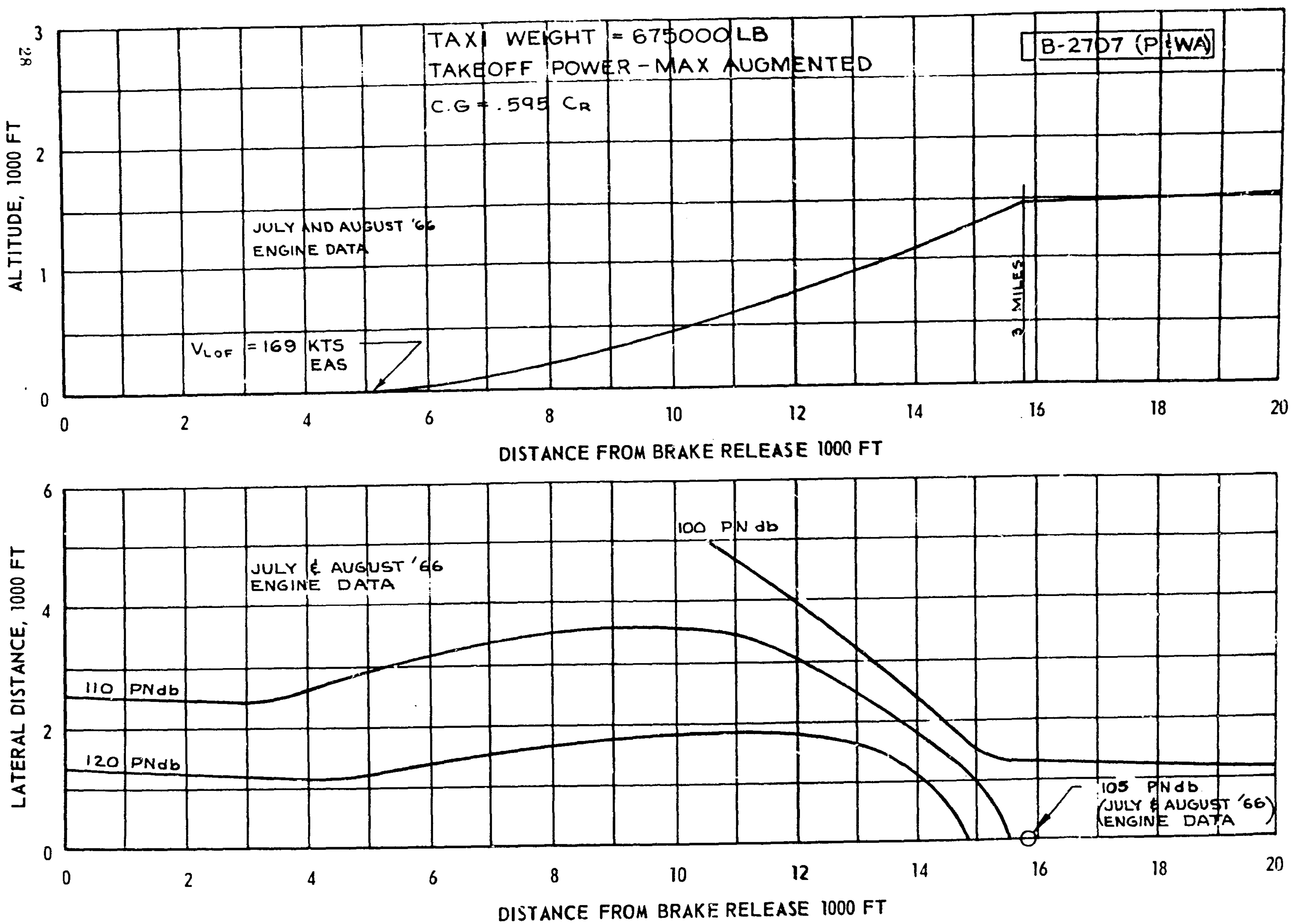


Figure 4–13. Noise Contours, International Mission, Standard Day Model B–2707 (P&WA)

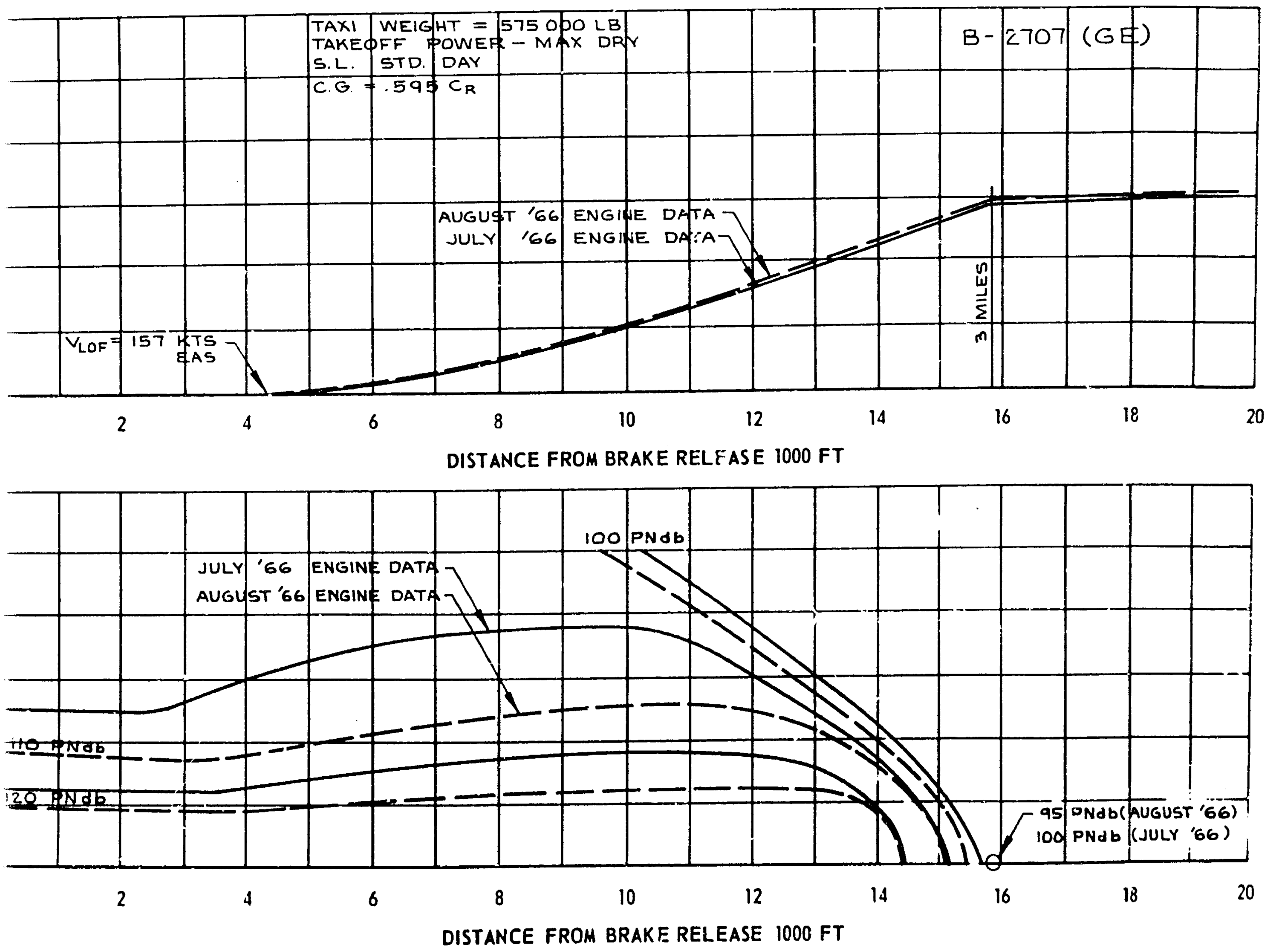


Figure 4–14. Noise Contours, Domestic Mission, Standard Day Model B–2707 (GE)

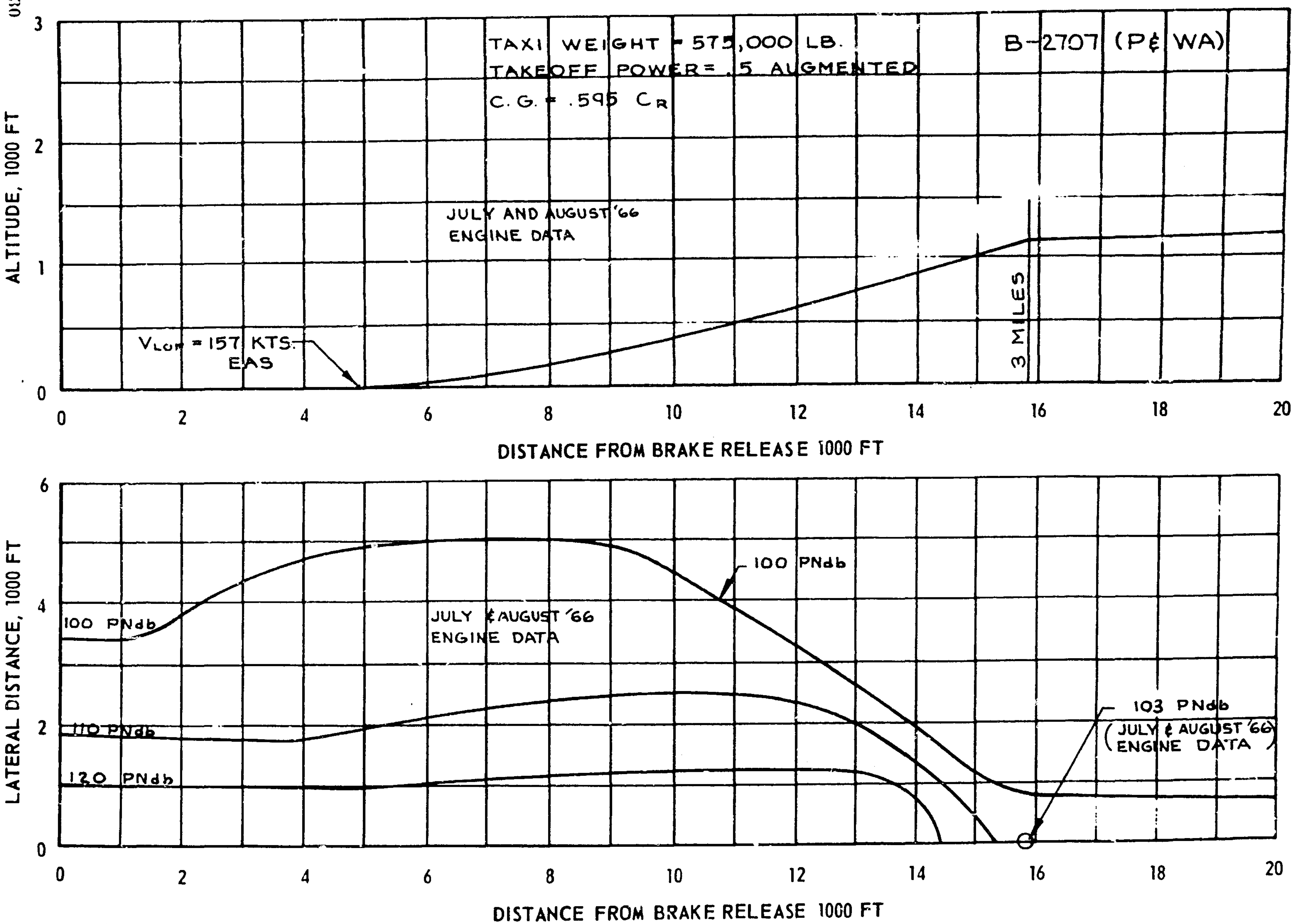


Figure 4–15. Noise Contours, Domestic Mission Standard Day Model B–2707 (P & WA)

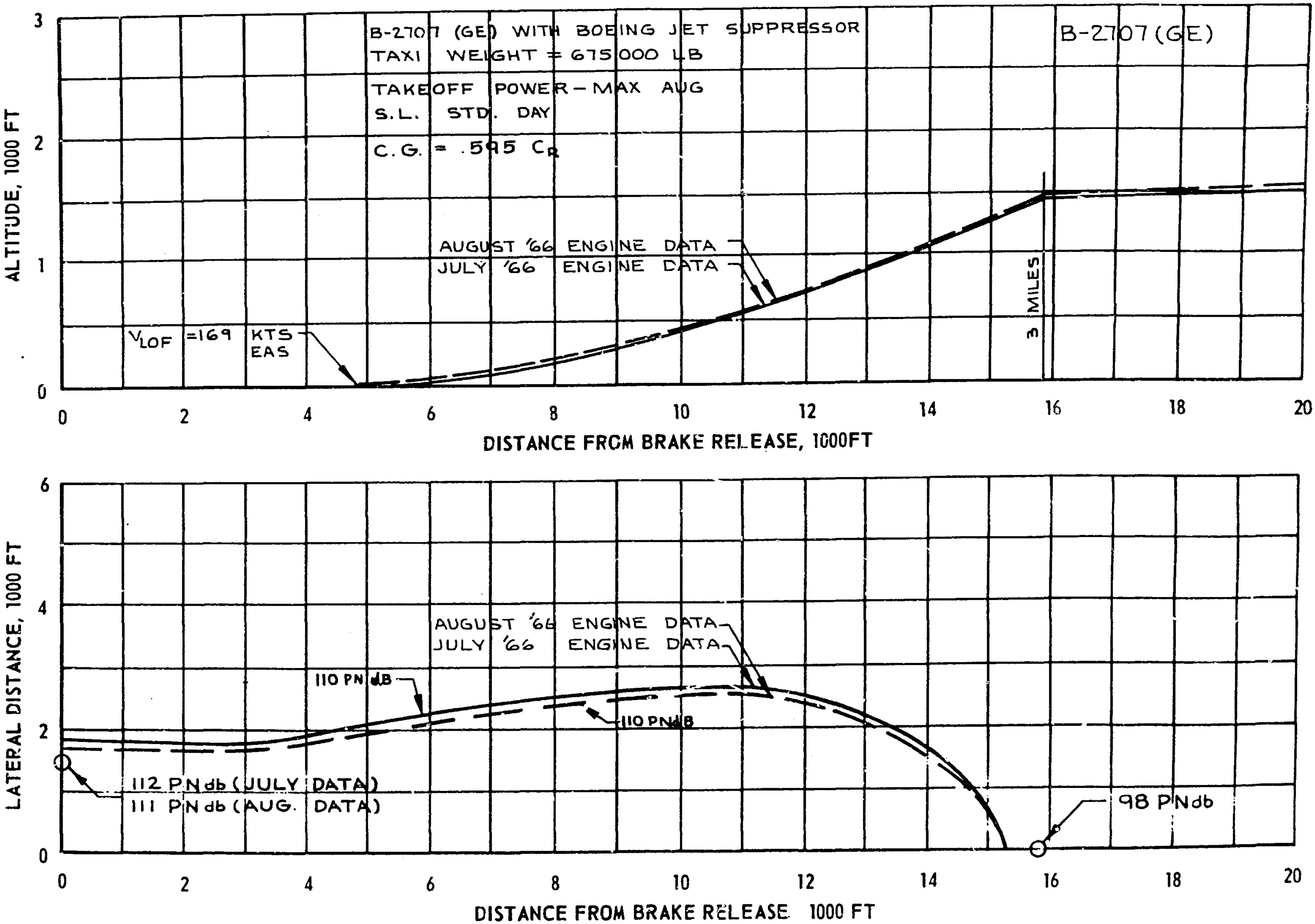


Figure 4–16. Noise Contours, Boeing Jet Suppressor, Model B–2707 (GE)

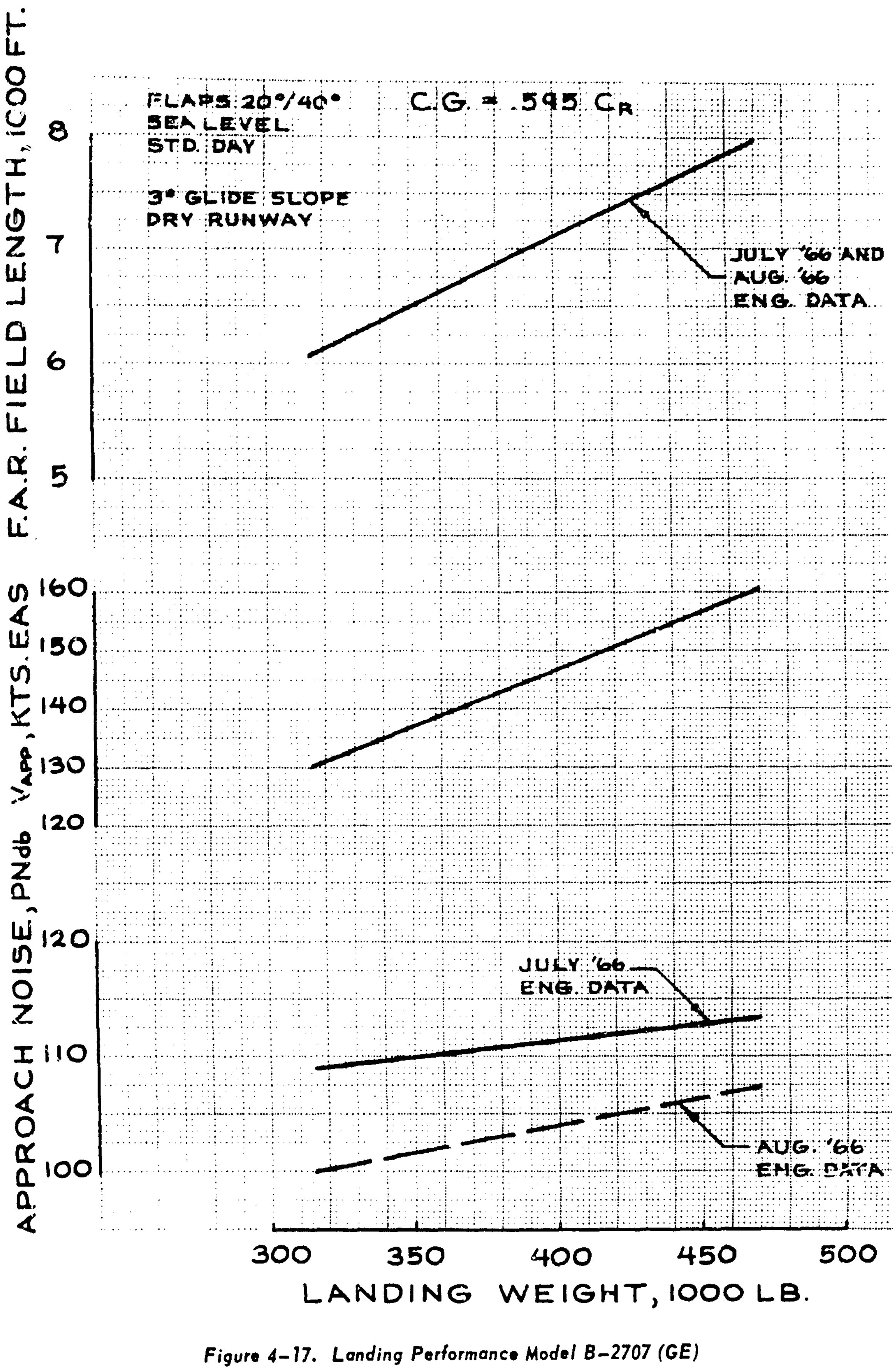


Figure 4-17. Landing Performance Model B-2707 (GE)

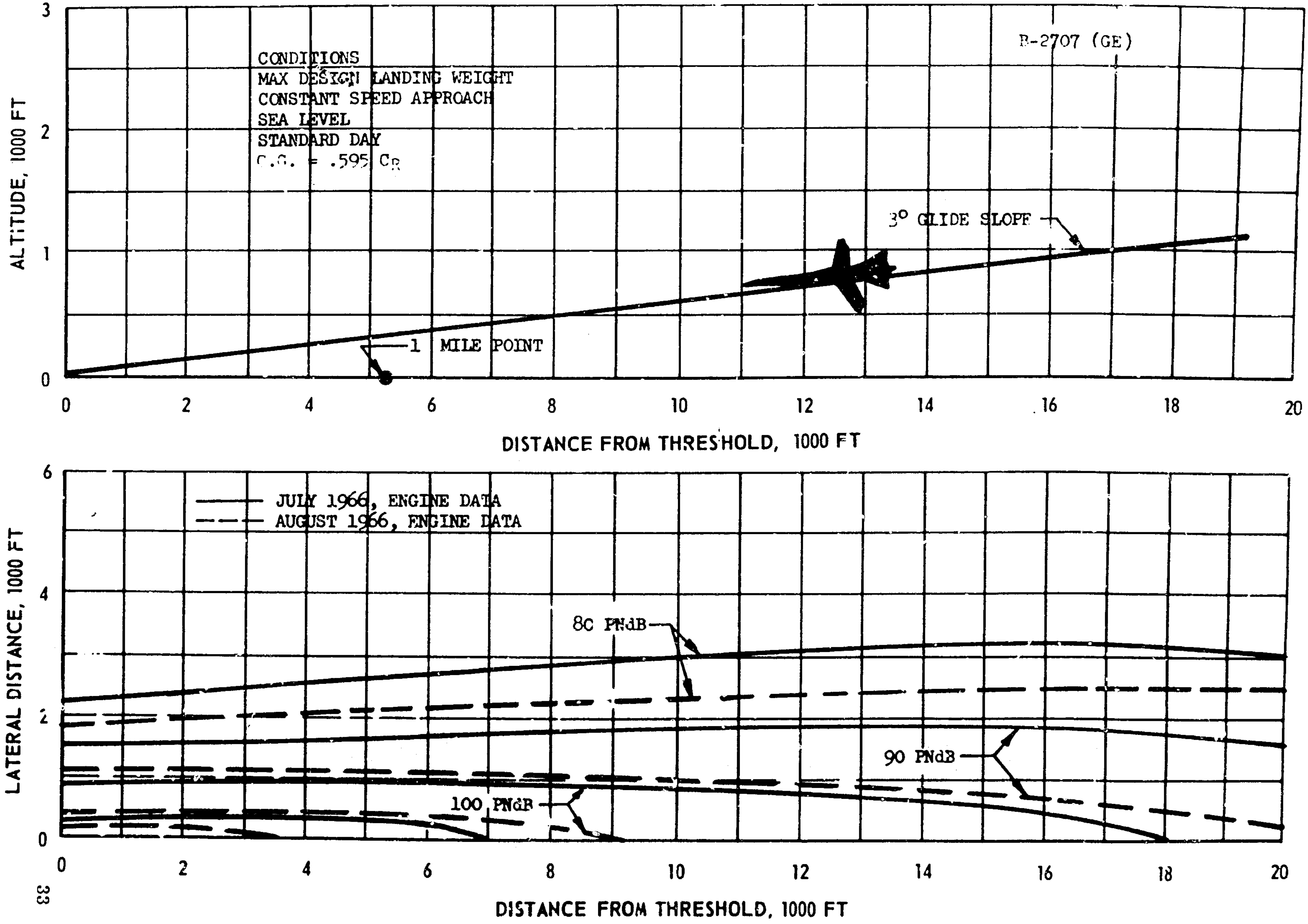


Figure 4-18. Landing Noise Contours, International Mission B-2707 (GE)

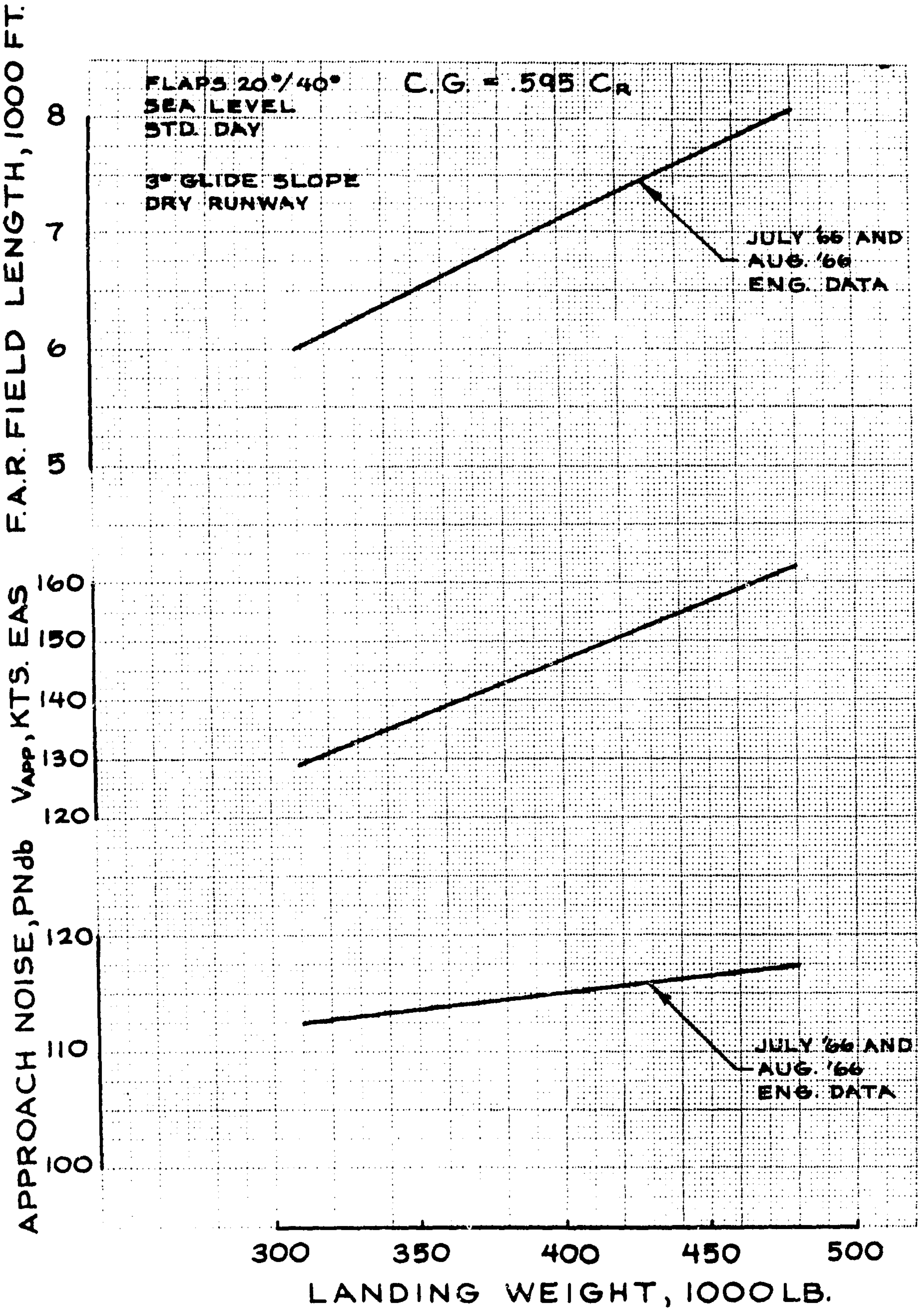


Figure 4–19. Landing Performance Model B-2707 (P&WA)